THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY

OF

LONDON.

SECOND SERIES.—BOTANY.

VOLUME I.

PART THE THIRD.

LONDON:

PRINTED BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET:

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE;

AND BY LONGMANS, GREEN, READER, AND DYER, PATERNOSTER-ROW.

M.DCCC.LXXVI.

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V. *On a Collection of Fungi made by Mr.* Sulpiz Kurz, *Curator of the Botanic Garden, Calcutta.* *By* Frederick Currey, *M.A., F.R.S., Sec.L.S.*

(Plates 19–21.)

Read June 4th, 1874.

THE fungi to which this paper relates were collected mostly in Pegu by Mr. Sulpiz Kurz, Curator of the Botanic Garden at Calcutta. I am not aware that any collections of fungi have heretofore been made in Pegu, and an interest therefore attaches to the present one as being so far the first of its kind. As might be expected, many well-known tropical forms occur. There are several species, especially amongst the *Polyporei*, which, although previously described, are by no means well known; and it will be seen that there are some new forms of considerable interest. In the examination of the plants I have had the advantage of access to Mr. Berkeley's valuable herbarium, for which, and for his kind assistance in the determination of some of the species, I am desirous of expressing my acknowledgments.

AGARICINI.

Several species of *Agaricus* accompanied the other fungi; but it is hopeless to attempt to name specimens of this genus unless they are accompanied by coloured drawings of the fresh plant, careful sectional figures, and notes of the colour and shape of the spores. Micrometric measurements of the spores should be added in all cases where practicable. Amongst the specimens were some which appeared to belong to *Ag. silvaticus*, Fr., and *Ag. fimicola*, Bolt., and others which were identical with or allied to *Ag. spadiceus*, Fr., and *Ag. picreus*, Fr. Others, belonging to the subgenera *Lepiota*, *Tricholoma*, *Volvaria*, *Psathyra*, and *Psathyrella*, were not further determinable. One small Agaric is noted as being used for food. It resembles *Ag. semiorbicularis*, Bull.; but that plant is not edible. Two species of *Marasmius* occur, one of which has not dried well: the other (No. 3472), in the dried state, is just like *M. ramealis*, Fr.; but Mr. Kurz describes it as *white* when fresh, so that it can hardly be that species.

Lentinus capronatus, Fr. Epicrisis, p. 390; Persoon in Freycinet's Voyage, t. 2. f. 3.—Myodwine, Evergreen Forests, Pegu. No. 2604.

This is an interesting series of specimens, varying in the size of the pileus from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inch. In three of the plants the pileus is distinctly zoned. The gills cannot be called denticulate, although some are very slightly uneven at the edge. The figure in 'Freycinet's Voyage' is very good, but the specimens there represented are small.

L. descendens, Fr. Epicr. p. 390.—Tonkyeghat, Pegu, Evergreen Forests. No. 2629.

This species was found by Afzelius in Guinea, in gravelly soil. It is figured by him in

the 'Fungi Guineenses,' t. x. fig. 22. The specimen is in bad condition, and I have some doubts about the species.

Lentinus furfurosus, Fr. Epicr. p. 391.—Yomah, Pegu. No. 3474*.

L. velutinus, Fr. Epicr. p. 392.—Yomah, Pegu. No. 3498.

L. glabratus, Mont. Cuba, p. 424. No. 1779.—North Rajmehal hills, N. Bengal.

There are but two specimens of this species, and they have not been very successfully dried. The margin of the pileus can hardly be called hairy; but in all other respects the plant agrees with *L. glabratus*.

L. Sajor Caju, Fr. Epicr. p. 393. Rumph. Amb. t. 56. f. 1.—South Andaman. Nos. 2560, 2561.

"Sajor Caju" is the Malay name of the plant.

L. exilis, Fr. Epicr. p. 393.—Tonkyeghat, Nakawa, Evergreen Forests, Pegu. No. 2592. Sittang valley, Pegu. Nos. 3487 & 3488.

L. inquinans, Berk., Hooker's Journal of Botany, 3rd series, vol. iv. p. 130, t. vii. f. 1.—Kemendine, Jack Tree Gardens, near Rangoon, Pegu. No. 2600.

I think there is no doubt about the species, although the single specimen gathered by Mr. Kurz varies from the type in some particulars. The gills are somewhat narrower, and the warts and the brown pubescence of the pileus have rubbed off in drying; but there are dark spots all over the pileus, showing the places where the warts were attached. The bristles have disappeared, except here and there at a short distance from the margin, where they are still plainly visible under a lens, and the transverse scales on the stem are not now to be seen. The latter, however, like the warts, may have been rubbed off in drying. Mr. Berkeley has noticed that in some dried specimens a pellicle separates from the umbilicus, carrying the warts with it and leaving the pileus smooth.

L. Kurzianus, n. sp. *Pileo* lento, infundibuliformi, furfuraceo-squamuloso, fusco; *stipite* brevi, fusco-ferrugineo, ad basin nigricante; *lamellis* profunde decurrentibus, læte rubiginosis.—Yomah range, Pegu. No. 3497.

This is a beautiful species, in many points resembling *L. furfurosus*, Fr., from which it differs in the deeply funnel-shaped pileus and in the colour of its gills. In *L. furfurosus* the mycelium (held together by the sand in which it grows) forms an indurated tuberiform root. In the specimens of the present species the stipes has the appearance of having been broken off in gathering; so that it is not improbable that a tuberoid radix may be present in the perfect state, which would bring the plant still nearer to *L. furfurosus*, Fr. The colour of the gills varies from a bright rust-colour to a greyish brown, according to the incidence of the light under which they are examined.

Plate 20. fig. 11. Plant, natural size.

L. cæspitosus, n. sp. Dense cæspitosus. *Pileo* infundibuliformi, squamis subconcentricis ornato; *stipite* versus basin attenuato; *lamellis* substipatis, decurrentibus, (siccis) brunneis.—Pegu. No. 2624. No special locality is given.

* In the specimens of this species the stems have been broken off short in gathering, so that there is no tuberiform radix, and the gills are too dark-coloured to be described as "*flavidis*;" but the plant comes so near in other respects to *L. furfurosus*, Fr., that I do not venture to propose it as a new species.

I find no species described which agrees with this. The plant is stated to be white when fresh. In the dried state it is of a brownish fawn-colour, the gills being somewhat darker than the pileus.

Plate 19. figs. 4 and 5. Fig. 4, a group of plants, natural size; fig. 5, a single plant.

Lentinus irregularis, n. sp. *Pileo* (sicco) nigricante, fragili, infundibuliformi; *lamellis* cinnamomeis, irregularibus, hic per totum stipitem decurrentibus, illic annulatim abruptis.—Karen country. Pine-forests from Theemeechu to Borkee. No. 2534.

There are four specimens of this species, in two of which the gills run down the whole length of the stem, whilst in the other two they terminate abruptly, and break off in a way very similar to what is seen in the British species *L. fimbriatus*, Curr. If the two latter specimens only had been examined, I should probably have referred them to *L. fimbriatus*.

Plate 19. figs. 14 and 15. Plants, natural size.

Schizophyllum commune, Fr. Several specimens of this species occur in Mr. Kurz's collection.—The localities are:—Botanic Garden, Calcutta, Nos. 1781 and 2649; Ross Island, South Andaman, No. 2562; Sikkim Himalaya, Nos. 2572 and 2575; Tonkyeghat, Pegu, No. 2598.

Lenzites albida, Fr. Epicr. p. 405.—Tonkyeghat, Pegu. No. 2601.

I have seen no specimens of *L. albida*, Fr. No. 2601 agrees with the description in the 'Epicrisis,' except in being stipitate and in the gills having a cinnamon-colour. Nothing is said by Fries as to the size of *L. albida*. The pileus in the present plant measures $\frac{7}{8}$ of an inch by $\frac{5}{8}$ of an inch, and at first sight much resembles *Panus stypticus*, Fr.; but the anastomosing gills show that it cannot be that species.

L. Palisoti, Fr. Epicr. p. 404.—Seven Pagodas, Evergreen Forests, Tonkyeghat, Pegu. No. 2590.

There is another specimen in the collection (No. 2604), which seems to be the same species, from the Botanic Garden, Calcutta.

POLYPOREI, Fr.

Polyporus (Mesopus) perennis, Fr. Epicr. 434; ib. Hym. Eur. 531.

Sent by Dr. Stoliczka from Penang. No. 2041.

P. (Mesopus) xanthopus, Fr. Epicr. 437.—Pegu, Nakawa, Evergreen Forests, Tonkyeghat, No. 2533; Sittang valley, Pegu, No. 3489; Yomah range, Pegu, No. 2627.

There is also a specimen from South Andaman, No. 2563.

P. (Mesopus) florideus, Berk., Hooker's Journal of Botany, 3rd series, vol. vi. p. 137.—Pegu, Karen country, Bookee ridges, 5000–6000 feet, Pine-forests, No. 2595.

This species was found by Dr. Hooker at Darjeeling, at a height of 7500 feet.

P. (Mesopus) hypoplastus, Berk., Hooker's Journal of Botany, vol. viii. p. 174.—Howrah district. On bamboo. No. 2652.

This species was first found by Mr. Spruce at Panuré. Mr. Berkeley has noticed that the pileus is sometimes lateral; and this is the case with three out of the four specimens sent by Mr. Kurz. Judging from Mr. Kurz's specimens alone I should have placed the plant in the division *Pleuropus*.

Polyporus (Mesopus) crassipes, n. sp. *Pileo* lignoso, infundibuliformi, fusco-purpureo, margine umbrino et zonato; *stipite* durissimo, badio, ad basin incrassato; *poris* minutissimis, stipite pallidioribus.—Yomah river, Pegu. There is no number to the specimen.

This plant resembles in some points *P. parvulus* and *P. carbonarius*, Fr., but differs widely in other respects. I do not know any species to which it can be referred.

Plate 19. fig. 13. Plants of the natural size.

P. (Pleuropus) sanguineus, Fr.

This common tropical species occurs in Mr. Kurz's collection from Mutlah, in Lower Bengal, No. 2031; from the Botanic Garden, Calcutta, No. 2682; and from Tongloo, Sikkim Himalaya, 5000–6000 feet, No. 2584.

P. (Pleuropus) modestus, Kunz, Fr. Linn. v. p. 519; Fr. Epicr. p. 444.—Yomah range, Northern Pegu, No. 2610.

This is the same species as *P cervino-nitens*, Schweinitz.

P. (Pleuropus) flabelliformis, Kl., Fries, Epicr. p. 444.—Yomah range, Pegu, No. 3491.

P. (Pleuropus) affinis, Fr. Epicr. p. 445.—Yomah range, Pegu, Nos. 2628 & 3490. Evergreen Forests, Bookee ridges, Karen country, 5000–6000 feet, No. 2617.

No. 2617 has a very short stem and an irregular margin, but I cannot make it out to be any other species.

P. (Pleuropus) picipes, Fr. Epicr. p. 440.—Botanic Garden, Calcutta, No. 2655.

There is also a specimen from Sikkim without a number.

P. (Pleuropus) lucidus, Fr. Epicr. p. 442.—Botanic Garden, Calcutta, No. 2684. The yellow form of the species.

P. (Pleuropus) amboinensis, Fr. Epicr. p. 442.—Karen country, Pegu, 4000 feet. No. 2636.

This is a very variable species, probably not distinct from *P. lucidus*, Fr.

P. (Pleuropus) Splitbergeri, Mont. Cent. ii. no. 83; Sylloge, p. 164. no. 522.—Nattoung Hills, Pegu, 6000–7000 feet. No. 2638.

Plate 19. figs. 2 and 3. Fig. 2, the under side of the plant; fig. 3, the upper side: natural size.

This *Polyporus* agrees almost to the letter with the description of *P. Splitbergeri* in the 'Sylloge,' although the character "contextu aureo-nitido" is hardly applicable to the present plant. In the figure the pileus appears zonate, but the apparent zones are rather imbrications produced by the successive growths of the pileus. In *Polyporus Nilgheriensis*, Mont. (Sylloge, p. 164. no. 523), a closely allied species, the pileus is described as "antice prole nova subimbricata," and this description is exactly applicable to the present specimen of *P. Splitbergeri*. This plant being stemless, it might be thought that it ought to be placed in the division *Apus*; but it clearly belongs to the "proliferans" division of Fries, as described in his 'Novæ Symbolæ Mycologicæ,' p. 161, in which division the stem is sometimes wanting.

P. (Pleuropus) brunneo-pictus, Berk., var.—Arracan, Kolodyne valley, on old wood. No. 2045.

Plate 19. figs. 11 and 12. Fig. 11, the under side; fig. 12, the upper side: natural size.

This plant comes so near to *P. brunneo-pictus*, Bk., that I do not venture to propose it as a new species. It differs in its obsolete stem and in the nature of its pores. In *P. brunneo-pictus* the apices of the pores are papular, with a central aperture; and slight traces of this structure may be seen at the extreme margin in Mr. Kurz's plant, in which, however, the pores are not generally porotheloid, although the dissepiments are unusually thick. *P. brunneo-pictus* is described in Hooker's Journal of Botany, 3rd series, vol. viii. p. 176.

Polyporus (Apus, Anodermei) funalis, Fr. Epicr. 459.—Lower Bengal, Mutlah tidal jungles. No. 2029.

This species is admirably figured in Afzelius's 'Fungi Guineenses,' t. i. f. 3.

P. (Apus, Anodermei) rubidus, Berk. London Journ. Bot. vol. vi. p. 500.—Pegu. Nos. 2621, 2622.

Plate 20. figs. 5 and 6. Fig. 5, the upper side; fig. 6, the under side of a plant: natural size.

The hymenium differs little in colour from the upper side of the pileus. The pores are very small, just visible to the naked eye. The plant varies in the brightness of its tint, although always exhibiting a tinge of flesh-colour. In one of Mr. Kurz's specimens the pilei are imbricated, and one has a distinct lateral stipes, showing a variability of habit. The species was first found by Gardner at Point de Galle, Ceylon, on fallen trees.

P. (Anodermei) incertus, n. sp. *Pileo* in centro tenuissimo, marginem versus incrassato et reflexo, leviter zonato, dilute cervino; *poris* amplis, profundis, irregularibus, cervinis.

Pileus very thin, almost obsolete, except at the margin, where it is thicker, reflexed, slightly zoned, and fawn-coloured. Pores large, deep, irregular, somewhat darker than the pileus.

Plate 19. figs. 6 and 7. Fig. 6, a portion (rather more than half) of a plant, natural size; fig. 7, a section.

This is a difficult plant to describe technically on account of its great irregularity of growth. It has the appearance of having grown in an almost resupinate position, but with the margin to a certain extent free all round. The figure will give a better idea of it than any amount of description. Its systematic position is doubtful. It is certainly not one of the veritable "Resupinati;" but whether it belongs to the "Anodermei" or the "Inodermei" is very difficult to decide in the dry state. It has no appearance of having ever been "succose;" but, on the other hand, I see no trace of a cuticle.

P. (Placodermei) applanatus, Fr.—Pegu, Tonkyeghat, Evergreen Forests, Tonnghoo. No. 2686.

P. (Placodermei) marginatus, Fr.—Bookee, Pine-forests, 4000–6000 feet, Karen country, Pegu. No. 2586.

P. (Placodermei) Persoonii, Fr.—Pegu, Nakawa, Evergreen Forests, Tonkyeghat. No. 2593.

P. (Placodermei) holosclerus, Berk. Lond. Journ. Bot. vol. vi. p. 479.—Pegu, Yomah, Myodwine, Evergreen Forests. No. 2614.

Polyporus (Apus, Placodermei) cinereo-fuscus, n. sp. *Pileo* dimidiato, lignoso, durissimo, margine tenui, basin versus incrassato, fusco-cinereo, rugoso-tuberculoso; *poris* minimis, cinereo-fuscis.

Pileus 1½–2 inches wide, of a dull brown colour, with blotches of black, thin at the margin but thickening rapidly towards the base, longitudinally rugose with tubercles; pores very minute, blackish brown, sometimes almost quite black.—Pegu, Nakawa, Evergreen Forests, Tonkyeghat. No. 2606.

Mr. Berkeley was inclined to refer this plant to his *Polyporus ferreus* (London Journ. Bot. vol. vi. p. 502. no. 175); but it differs from that species in its dark pores and in some other characters. It is allied to *P. fasciatus* and *P. supinus* of Swartz.

Plate 19. fig. 1. Plant, natural size.

P. (Inodermei) cinnabarinus, Fr. Epicr. p. 473.—On old logs, Botanic Garden, Calcutta. No. 2681.

P. (Inodermei) scruposus, Fr. Epicr. p. 473.—Martaban Hills, Shan toung gyre toung, 3800 feet. No. 3492.

P. (Inodermei) Feei, Fr. Epicr. p. 476.—Pegu, Yomah. No. 3493.

P. (Inodermei) versicolor, Fr. Epicr. p. 478.—Sikkim Himalaya, 7000 feet, on dead wood. No. 2567.

P. (Inodermei) pinsitus, Fr. Epicr. p. 479.—Nattoung ridges, Karen country, 6000 feet. No. 2608.

A. (Inodermei) cinerascens, Fr. Epicr. p. 481.—Yomah, Northern Pegu. No. 2609.

Fries describes the pileus in his *P. cinerascens* as fuscous, and the pores as cinereous. In Mr. Kurz's plant the pileus is rather ochraceous than fuscous, and the pores are reddish brown. These differences in colour are hardly sufficient to separate it as a species.

P. (Inodermei) anebus, Berk. Lond. Journ. Bot. vol. vi. p. 504.—Tonkyeghat, Pellowa, Evergreen Forests, Pegu. No. 2599.

This is a small thin form of Mr. Berkeley's species. From Mr. Berkeley's remarks (*loc. cit.*) it seems to be a variable plant.

P. (Inodermei) xerophyllaceus, Berk., Hook. Journ. Bot. 3rd series, vol. viii. p. 200. No. 2658.—Botanic Garden, Calcutta, on old logs in the rainy season.

Mr. Kurz's specimens agree very well with Mr. Berkeley's description. In some the pilei are confluent laterally, in others imbricated. I should rather have placed the plant in the "Anodermei," but have retained Mr. Berkeley's division.

Plate 20. figs. 1 and 2. Plants, natural size.

Trametes lobatus, Berk., Hook. Journ. Bot. 3rd series, vol. iii. p. 84.—N. Bengal, Sikkim Terai, on old logs. No. 2569.

T. umbrinus, n. sp. *Pileo* resupinato, effuso-reflexo, lobato, subtomentoso, leviter zonato; *poris* amplis, dentato-laceris. No. 2611.—Pegu, Nakawa, Evergreen Forests, Tonkyeghat.

Plate 21. fig. 4. Plants, natural size.

It is difficult to say whether the larger specimen is a single plant or a mass of

confluent pilei. The pores underneath the slightly reflexed marginal lobes are at right angles with the pileus. In the centre the pores become elongated and decurrent, overlapping one another in an imbricated manner.

Trametes occidentalis, Fr. Epicr.—Botanic Garden, Calcutta. On old logs in the rainy season. No. 2656.

I have had a little doubt about this species, as the pileus is not "effuso-reflexed," which is one of the characters of *T. occidentalis*. In Mr. Kurz's specimens the pilei are dimidiate. Substituting "dimidiato-" for "effuso-reflexo" in Fries's description, the latter applies exactly to Mr. Kurz's plant.

T. cingulatus, Berk., Hook. Journ. Bot. 3rd series, vol. vi. p. 164.—Pegu, Yomah. No. 3475.

Other specimens in Mr. Kurz's collection from the Botanic Garden, Calcutta (Nos. 2679 & 2685), show that this species varies a good deal in the thickness and in the pubescence of the pileus, the latter being sometimes silky, sometimes woolly in its appearance. The pubescence, of whichever kind, is always slight, a lens being almost necessary to see it distinctly.

Dædalea.

Dædalea tenuis, Berk.—Pegu, Yomah. No. 2603.

Another specimen of this species from South Andaman Island occurs in Mr. Kurz's collection.

D. discolor, Fries, Epicr. p. 494.—Pegu, Yomah. No. 3503.

D. zonata, Fr. Epicr. p. 494.—Pellowa, Evergreen Forests, Tonkyeghat, Pegu. No. 2589.

I have not seen specimens of Fries's *D. zonata*. The present plant only differs from Fries's description in the pileus being wrinkled and very slightly pubescent, characters which hardly justify its being made a new species. I should place it under *D. zonata* as var. *rugoso-pubescens*.

Hexagonia, Fr.

Hexagonia polygramma, Mont. Fr. Epicr. p. 497; Mont. Sylloge, p. 169; Cuba Crypt. (Ramon de la Sagra), p. 379, t. 14. f. 3.—Pellowa, Evergreen Forests, Tonkyeghat, Pegu. No. 2597.

H. tenuis, Fr. Epicr. p. 498.—Pegu, Elephant Point. On old trees along the shore. No. 3484.

This is exactly the plant of Fries, agreeing in every particular. There are two other forms (both from Yomah) in the collection (Nos. 3494 & 3505), which I cannot satisfactorily separate from *H. tenuis*. No. 3494 differs in having a darker-coloured pileus and smaller pores, the latter being brown, without the grey tinge of the pores of *H. tenuis*. In No. 3505 the pileus and pores are precisely similar in colour to those of No. 3494, but are a good deal larger.

Hexagonia Kurzi, n. sp. *Pileo* coriaceo, glabro, orbiculato aut reniformi aut dimidiato, corrugato, zonato, rubro-fusco; *alveolis* amplis, intus canescenti-fuscis, acie cinnamomea.—Mutlah. No. 2028.

Plate 20. figs. 3, 4, and 7. Figs. 3 and 7, the upper side; fig. 4, the under side of different plants: natural size.

This species comes very near to *H. nitida*, D.R. et M. It differs in having the pileus sometimes quite circular, and in the colour of the pores, which are of a pale bright grey in the inside, with the edge of a distinctly cinnamon-colour.

HYDNEI.

Hydnum udum, Fr. Epicr. p. 517—Mutlah, Calcutta. No. 2030.

Tremellodon gelatinosum, Fr. Hymenomycetes Europæi, p. 618.—Sikkim, 7000–8000 feet. No. 2573.

Tremellodon is a genus formed by Fries to include *Hydnum gelatinosum*, Scop., and *H. auriculatum*, Fr. These plants have the aculeate hymenium of *Hydnum*, but the fructification of *Tremella*. See Linn. Journ. vol. v. p. 181.

Irpex flavus, Kl.; Fries, Epicr. p. 522.—Arracan, Baronga Islands, on old wood, 1000 feet. No. 2047.

I. pallescens, Fr. Epicr. p. 522.—Yomah, Pegu. No. 3495.

There is one other *Irpex* in the collection (No. 3486) from the Sittang valley, Pegu. It has been partially destroyed by insects, and is not certainly determinable; but it must, I think, be either *I. flavus*, or *I. sinuosus*, Fr.

Grandinia granulosa, Fr. Epicr. p. 527.—Pellowa, Evergreen Forests, Tonkyeghat, Pegu. No. 2594.

AURICULARINI.

Thelephora pusilla, n. sp. Pusilla, fuscescens, simplex vel ramosa, sursum cristato-divisa.—Sikkim Himalaya, 2000–2500 feet. No. 2570.

This species is evidently allied to *T. cristatella*, B. & Br. (a Ceylon plant), but it differs in the colour, which varies from light to dark brown, and in the divisions, which are rather clavate than acute.

Plate 21. fig. 9. Plants, natural size.

T. palmata, Fr. Epicr. p. 537.—Botanic Garden, Calcutta. On bamboo-trunks. No. 2661.

Stereum elegans, Fr. Epicr. p. 543.—In bamboo-jungles, but the locality is not given. No. 1792. Lower Pegu, junction of Pegu river and Khayasoo Choung. No. 2631.

The specimens under the latter number are very small, but there is no doubt about the species.

S. ostrea, Fr. Epicr. 547.—Sikkim Himalaya, 4000–6000 feet. No. 2579.

S. lobatum, Fr. Epicr. p. 547.—Pegu, Tonkyeghat, the seven Pagodas. No. 2596.

In Mr. Kurz's collection there is another specimen of *S. lobatum* (No. 2564), from Escape Bay, South Andaman Island.

Stereum scytale, Berk., Hook. Journ. Bot. 3rd series, vol. vi. p. 170.—Pegu, Karen Hills, Bookee ridges, 5000–6000 feet. No. 2618. Pegu, Yomah. No. 3504.

Plate 19. figs. 8, 9, and 10. Fig. 8, the under side; figs. 9 and 10, the upper side of different plants: natural size.

This species was found by Drs. Hooker and Thomson in the Khasia mountains, and by Capt. (now General) Strachey in the Western Himalayas.

S. adustum, Lev. Ann. d. Sc. Nat. (1844), 3rd series, vol. ii. p. 213.—Southern Yomah, Pegu. No. 2602.

This is more properly a *Hymenochæte*.

S. papyrinum, Mont. Sylloge, p. 178.—Pegu, Timeokee, Evergreen Forests. No. 2623.

S. medicum, n. sp. Effusum, resupinatum, tenuissimum, margine subhirsuto; *hymenio* inæquali in prominentiis rotundis elevato, fusco-tabacino, subvelutino.—Sikkim, 5000–6000 feet. No. 2582.

This is a very curious production: the pileus is very thin, but the plants grow together in a stratified mass, the mass having exactly the appearance of being composed of thin layers of tobacco. It is used by the Lepchas in medicine, and has a native name.

Plate 20. figs. 9 and 10. Fig. 9, a portion (about half) of a plant; fig. 10, a section: natural size.

S. cyathiforme, n. sp. Cyathiforme, extrinsecus hirsutum, margine inflexo; *hymenio* lævi ad marginem cyathi pallide umbrino, basin versus rubro-fusco.—Pegu, Karen Hills, Bookee ridges, 5000–6000 feet. No. 2619.

Plate 21. fig. 1. Plants, natural size.

This is a very pretty plant, looking like a *Crucibulum* without sporangia.

Corticium violaceo-lividum, Fr. Epicr. p. 564.—Pegu, Yomah. No. 3476.

C. lævigatum, Fr. Epicr. p. 565.—Pegu, Yomah. No. 3507.

C. Mougeotii, Fr. Epicr. p. 558.—Sikkim Himalaya, Phalloot, on dead trees, 11,000–12,000 feet. No. 2571.

Guepinia ramosa, n. sp. Cæspitosa, simplex vel ramosa; *ramis* apice bifurcatis vel cristatis; *hymenio* aurantiaco; *stipite* subtus cinerascente.—Arracan, Kolodyne valley, on old wood. No. 2044. Howrah district, on old logs. No. 2640.

Plate 21. figs. 2 and 3. Plants, natural size.

Varying from $\frac{1}{4}$ to 1 inch in height, and from the simple forms of fig. 3 to the ramose state of fig. 2.

CLAVARIEI.

Calocera viscosa, Fr. Epicr. p. 581.—Seebpore, Lower Bengal. No. 2196.

Typhula fuscipes, Fr. Epicr. p. 586.

A specimen of this species occurs with No. 2567 (*Polyporus versicolor*).

TREMELLINI.

Tremella foliacea, P. Fr. Syst. Myc. vol. ii. p. 212.—Sikkim Himalaya, on shrubs, 10,000 feet. No. 2580.

Hinneola auricula Judæ, Fr. Hym. Eur. p. 695.—Nakawa, Evergreen Forests, Tonkyeghat. No. 2591.

H. auricula Canis, Fr. Syst. Myc. vol. ii. p. 222 (sub *Exidia*).—Pegu, Northern Yomah, on logs. No. 2615.

NIDULARIACEI.

Cyathus intermedius, Mont. Sylloge, p. 284.—Seebpore, Lower Bengal. No. 2198.

This plant agrees very well with Montagne's species, but it is not striate within. I do not observe the blackness in the substance of the sporangia noticed by Montagne; but this feature probably depends upon age.

LYCOPERDACEI.

Lycoperdon gemmatum, Fr. Syst. Myc. vol. iii. p. 36.—Sikkim Himalaya, 7000–8000 feet. No. 2576.

Spores globose, nearly 0·0002 inch. No. 2581, also from Sikkim Himalaya, 9000–10,000 feet, and No. 2653, from the Botanic Garden, Calcutta (in bamboo-thickets amongst dead bamboo remains), may be forms of *L. gemmatum*, Fr.; but there are no notes, and dried *Lycoperdons* are most difficult to determine.

L. pusillum, Fr. Syst. Myc. vol. iii. p. 33.—Lower Pegu, Kayosoo Choung, in elephant-grass jungles. No. 2630.

L. brasiliense, Fr. Syst. Myc. vol. iii. p. 40.—Pegu, Nakawa, Evergreen Forests, Tonkyeghat. No. 2635.

The specimens are, unfortunately, in very imperfect condition; but the peridium is membranous and punctate, the flocci broad and lax, and it grows on wood. It seems to agree sufficiently well with Fries's species. It is accompanied by *Hypoxylon marginatum*, Schw.

TRICHODERMACEI.

Trichocoma paradoxum, Jungh. Sikkim Himalaya, 6000–7000 feet. On mossy dead stems. No. 2585.

MYXOGASTRES.

Trichia pyriformis, Hoffm. On wood, with No. 2585 (*Trichocoma paradoxum*).

Arcyria umbrina, Fr.—Pellowa, Evergreen Forests, Tonkyeghat, Pegu. No. 2626.

HELVELLACEI.

Peziza aurantia, Pers. Fr. S. M. ii. p. 49.—Sikkim, great road, on earth. No. 2578.

P. rutilans, Fr. S. M. ii. p. 68.—Junction of the Choungmenal Choung and Tonkyeghat rivers. On mud banks. No. 2587.

Helotium citrinum, Fr. *Peziza citrina*, Fr. S. M. ii. p. 131.—Sikkim Himalaya, 5000–7000 feet. On rotten wood. No. 2583.

SPOROCYBACEI.

Stilbum inconspicuum, n. sp. Solitarium vel cæspitosum, minutissimum; *capitulo* subgloboso, albido; *stipite* badio, deorsum leviter incrassato; *sporis* ellipticis, nucleo excentrico ornatis, 0·0002 unc. longis.—Seebpore, Lower Bengal. No. 2197.

S. erythocephalum, Dittm. var.—On dead bamboo-stems, Botanic Garden, Calcutta, rainy season. No. 2639.

This plant hardly differs from *S. erythrocephalum*, Dittm.; but the stem is only very delicately pilose, with silky adpressed hairs.

SPHÆRIACEI.

Xylaria digitata, Grev. *Sphæria digitata*, Fr. S. M. ii. p. 326.—Botanic Garden, Calcutta. On moist logs. No. 1791.

X. tabacina, Kickx.—Sikkim Himalaya, 7000–8000 feet. On old fallen trees. No. 2575.

X. guyanensis, Mont. Sylloge, p. 202.—Tonkyeghat, Evergreen Forests, Pegu. No. 2625.

X. polymorpha, Grev. *Sphæria polymorpha*, Fr. S. M. ii. p. 326.—Botanic Garden, Calcutta. On old logs in the shade, rainy season. No. 2659.

X. hypoxylon, Grev. *Sphæria hypoxylon*, Fr. S. M. ii. p. 327.—Arracan, Baronga Island, on old tree-stumps. No. 2046. Botanic Garden, Calcutta, on old logs, rainy season. No. 2657.

X. Kurziana, n. sp. Solitaria vel cæspitosa, vel etiam connata, $\frac{1}{4}$–1 unc. longa; *capite* castaneo subhemisphærico, peritheciis prominentibus scabro; *sporidiis* nigro-fuscis, amygdaloideis, 0·0006–0·0007 unc. longis.—On brick-laid paths where fire had been burnt. Botanic Garden, Calcutta, rainy season. No. 2650.

Plate 21. fig. 8. Plants, natural size.

The dried plants required to be moistened to bring out the colour, which is a chestnut-brown. Mr. Kurz describes them as yellow at first and then brown. There is another *Xylaria* in the collection (No. 1783, from the Calcutta Botanic Garden), which seems to be the same as No. 2650. The habitat, viz. brick-laid soil upon which fires had been burnt, is somewhat peculiar for a *Xylaria*.

X. flagelliformis, n. sp. Solitaria vel cæspitosa, simplex vel furcata, flagelliformis, colore carneo; *peritheciis* ——?—On earth, Sittang valley, along the base of the Yomah range, Pegu. No. 3485.

Plate 21. fig. 5. Plants, natural size.

X. mutabilis, n. sp. Solitaria vel cæspitosa vel connata, simplex vel ramosa, vel cristata; *stipite* nigro, rugoso, interdum profunde sepulto; *capite* elongato, vegetante carneo, sicco pallide umbrino, ostiolis nigris prominentibus scabro; *sporidiis* uniseriatis, nigro-fuscis, irregularibus (reniformibus, subellipticis vel subglobosis), minutissimis, vix 0·0001 unciæ attinentibus.—On brick-laid paths in the Botanic Garden, Calcutta. Very common in the rainy season. No. 1790.

Plate 21. figs. 10 and 11. Plants in different states, natural size.

This plant is remarkable for its irregular growth, the small size of its sporidia, and the

densely crowded state of the asci, which are often difficult to distinguish. I do not know any species of *Xylaria* with similar fructification.

Hypoxylon suborbiculare, Welw. & Curr. Trans. Linn. Soc. vol. xxvi. p. 281.—On old logs, Botanic Garden, Calcutta. No. 1809.

Mr. Kurz's specimens exhibit in section a browner and more corky substance than the typical *H. suborbiculare*; but I see no reason to doubt the identity of the plants. The difference is probably due to age.

H. concentricum, Bolt. On old wood, Botanic Garden, Calcutta. No. 1810.

H. marginatum, Schw. This species occurs (as above mentioned) upon the wood to which *Lycoperdon brasiliense* was attached.

Diatrype rugosa, n. sp. Irregularis; *stromate* rugoso vel depresso et marginato, intra et extra nigro; *peritheciis* in stromate sepultis, plus minus biserialibus; *sporidiis* irregularibus, globosis, ellipticis vel pyriformibus, 0·0005–0·0006 unc. longis.

On hard wood. Yomah, Pegu. No. 3471.

The stroma in this species occurs in minute rounded patches, sometimes it is prominent and rugose, sometimes depressed, with a margin, and then (under a lens) looking very like a *Patellaria*.

Hypocrea variabilis, n. sp. Statu juniore placentiformis, disco vel umbone concentrico ornata, colore citrino; statu adulto subglobosa vel irregularis, rugosa, colore umbrino; *sporidiis* ——.

Hab. On living leaves of bamboo, Yomah, Pegu. No. 3480.

Plate 21. figs. 6 and 7. Fig. 6, part of a leaf with plants, natural size; fig. 7, a plant, magnified.

Sphæria phaselina, Mont. Sylloge, p. 239.

Hab. Nakawa, Evergreen Forests, Tonkyeghat, Pegu.

S. sublimbata, D. R. et Mont. Fl. Alg. p. 498; Sylloge, p. 228.

Apparently on stems of *Thysanolæna acarifera*, Kambala toung, top.

Micropeltis applanata, Mont. Sylloge, p. 245.

On Girroniera leaves, Mangrove Bay, South Andaman Island. No. 2565.

Fumago salicina, Tul. Sel. Fung. Carp. vol. ii. p. 280.

On *Sphenodesma erycibordes*, Pz., Wa-choung, Yomah, Pegu. No. 3482.

Nectria Eugeniæ, n. sp. *Peritheciis* pallide citrinis, tomentosis, in stromate concolori collocatis vel ejusdem marginem amplectentibus; *sporidiis* —— ?

On dead leaves of *Eugenia*. Yomah, Pegu. No. 3479.

This is a very pretty species. The perithecia for the most part are seated round the base of the stroma, the colour of which is rather darker than that of the perithecia.

Graphiola Phœnicis, Poit.—On leaves of *Phœnix paludosa*. Calcutta. No. 1744.

The systematic position of this curious plant has not yet been satisfactorily determined. Some years ago I examined with great care some specimens kindly furnished to me by the late Sir William Hooker, and the results of my observations were published in the Microscopical Journal in 1859 (1st series, vol. vii. p. 225). My conclusions, however, do not coincide with those of Montagne, whose account of the plant is to be found in the 'Annales des Sciences Naturelles,' 4th series, vol. xii. p. 188.

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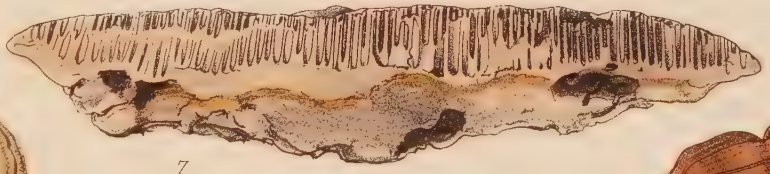
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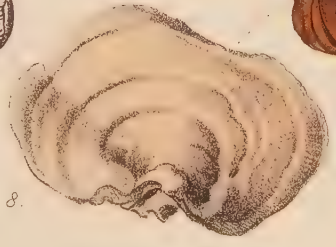
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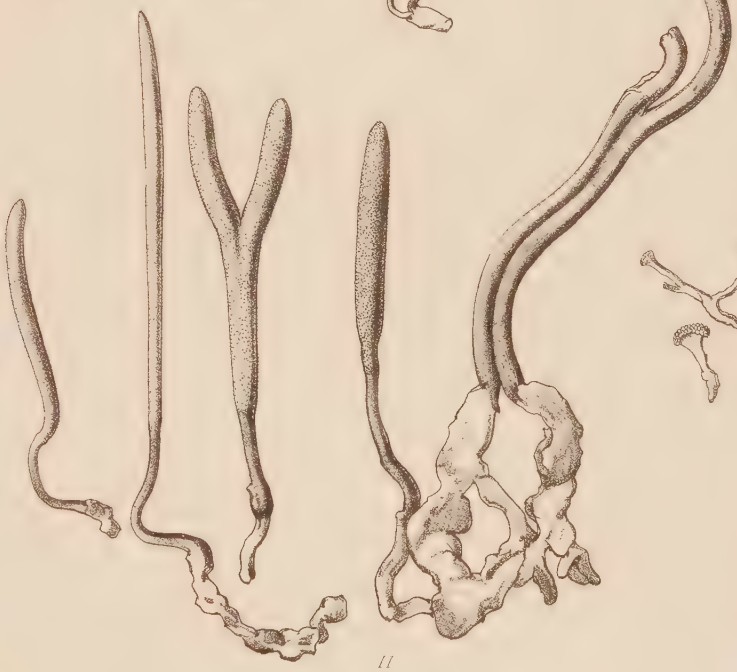

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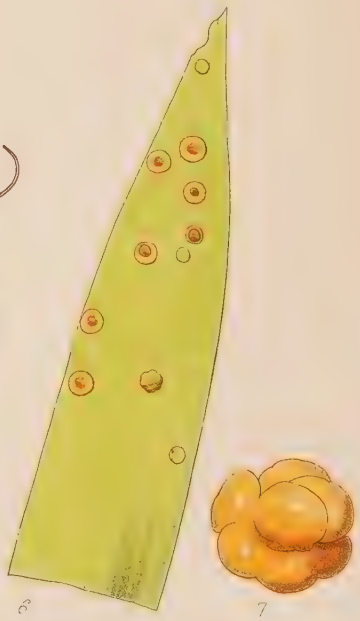

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DESCRIPTION OF THE PLATES.

All the figures except fig. 7, Plate 21, are drawn to the natural size.

Plate 19.

Fig. 1. *Polyporus cinereo-fuscus*, n. sp.
Figs. 2 and 3. *Polyporus Splitbergeri*, Mont. Fig. 2, the under side; fig. 3, the upper side.
Figs. 4 and 5. *Lentinus cæspitosus*, n. sp. Fig. 4, a group of plants; fig. 5, a single plant.
Figs. 6 and 7. *Polyporus incertus*, n. sp. Fig. 6, a portion (rather more than half) of a plant; fig. 7, a section.
Figs. 8, 9, and 10. *Stereum scytale*, Berk. Fig. 8, the under side; figs. 9 and 10, the upper side of different plants.
Figs. 11 and 12. *Polyporus brunneo-pictus*, Berk., var. Fig. 11, the under side; fig. 12, the upper side.
Fig. 13. *Polyporus crassipes*, n. sp.
Figs. 14 and 15. *Lentinus irregularis*, n. sp.

Plate 20.

Figs. 1, 2, and 8. *Polyporus xerophyllaceus*, Berk.
Figs. 3, 4, and 7. *Hexagonia Kurzi*, n. sp. Figs. 3 and 7, the upper side; fig. 4, the under side of different plants.
Figs. 5 and 6. *Polyporus rubidus*, Berk. Fig. 5, upper side; fig. 6, under side.
Figs. 9 and 10. *Stereum medicum*, n. sp. Fig. 9, a portion (about half) of a plant; fig. 10, a section.
Fig. 11. *Lentinus Kurzianus*, n. sp.

Plate 21.

Fig. 1. *Stereum cyathiforme*, n. sp.
Figs. 2 and 3. *Guepinia ramosa*, n. sp.
Fig. 4. *Trametes umbrinus*, n. sp.
Fig. 5. *Xylaria flagelliformis*, n. sp. Plants, natural size.
Figs. 6 and 7. *Hypocrea variabilis*, n. sp. Fig. 6, part of a leaf with plants, natural size; fig. 7, a plant magnified.
Fig. 8. *Xylaria Kurziana*, n. sp.
Fig. 9. *Thelephora pusilla*, n. sp.
Figs. 10 and 11. *Xylaria mutabilis*, n. sp. Plants in different states. In some of the specimens, notably in the large specimen on the right of fig. 11, fragments of brick remain attached to the bases of the plants.

VI. *Preliminary Note on the rate of Growth of the Female Flower-stalk of* Vallisneria spiralis, Linn. *By* Alfred W. Bennett, *M.A., B.Sc., F.L.S., Lecturer on Botany at St. Thomas's Hospital.*

Read November 4th, 1875.

Although the extraordinary rapidity of growth of the peduncle of the female flower of *Vallisneria spiralis* (probably one of the most remarkable instances to be found in the vegetable kingdom) appears to be familiar to botanists, I have been unable to find any record of actual measurements. The present communication to the Society I prefer to call a "Preliminary Note," inasmuch as a much more extensive series of experiments than I have at present had the opportunity of making will be required before the subject can be considered exhausted.

The object of the great length attained by the female flower-stalk is well known. The flower is by this means brought to the surface of the water in which it grows, which I should infer, from the length it attains (though I do not recollect any exact record of this), to be from three to four feet. It is there fertilized by the pollen supplied by the male flower, which, growing submerged on a short peduncle, breaks off from it and rises to the surface, where it floats about until the pollen meets with a female flower, the latter after impregnation being again carried, by the spiral coiling of the peduncle, beneath the surface, where it ripens its seeds.

The first memoir, as far as I have been able to trace, of the structure of *Vallisneria* is by E. J. Quekett, "Observations connected with the Anatomy and Physiology of *Vallisneria spiralis*," in the first and only volume of the 'London Physiological Journal' for 1843. The mode of fertilization and the phenomena of rotation within the cells of the leaves are here described; and the description appears to be the basis of the ordinary accounts found in works on descriptive botany. A far more minute and accurate account of the structure of the plant is by Chatin, in his 'Mémoire sur le *Vallisneria spiralis*, Linn., considéré dans son organographie, sa végétation, son organogénie, son anatomie, sa tératologie, et sa physiologie,' 1855. The author of this memoir points out the singular error into which previous writers have fallen, in describing the peduncle of the female flower as originally coiled up spirally and unrolling towards the period of impregnation, an error repeated by Richard, Turpin, and even by Grenier and Godron in their 'Flore de France,' and by nearly all subsequent writers, whether scientific or popular, and forming the text of one of Erasmus Darwin's most poetical images in his 'Loves of the Flowers.' Chatin states, and with perfect correctness, that "la hampe des fleurs femelles, d'abord droite, ne se déroule jamais." Neither of these authors, however, gives any details on the special subject of this paper.

The first flower noticed on the plants growing in my aquarium, where the water is about 8 inches deep, was on July 19th of the present year, when the total length of the

peduncle was 26 in., lying in several long coils on the surface. I am almost certain that the whole of this growth, at all events in excess of the 8 in. which would have brought the flower-bud to the surface, had taken place within the preceding 48 hours. At 10 o'clock the next morning the peduncle was again measured, and had attained the extraordinary length of 38 in., or an increase of 12 in. in 24 hours. At 4 P.M. it measured 41 in.; at 9 A.M. on the 21st $42\frac{1}{4}$; and at 10 A.M on the 22nd it had attained its ultimate length of 43 inches. The window in which the aquarium was placed had a south-west aspect; but the climatal conditions were by no means favourable to rapid growth, the temperature being rather low, the sun scarcely visible during the whole time, and the rainfall excessive. Lest it should be thought that this is the result of an error of observation, I may mention that Mr. W. W. Reeves, the Secretary of the Microscopical Society, informs me in a note that he has observed an even greater rapidity of growth than this. I do not know whether any other instance is known of a single internode attaining a length of over $3\frac{1}{2}$ feet. This flower was never fertilized (there being at that time no male plant in my aquarium), but remained open, and the stigmas in an apparently receptive condition, nine days longer, till July 31st, when I left home. During this time no actual recoiling of the peduncle had taken place, though it displayed a strongly marked waviness.

It did not occur to me, until the flower-stalk had nearly completed its growth, that it would be interesting, in accordance with the plan proposed by Prof. Sachs, to ascertain in which portion of the flower-stalk the main portion of this rapid increase took place, though a few measurements which I did make convinced me that the apical portion was that in which there was the greatest activity.

I was unable to renew my observations before the latter part of September, in which interval a large number of female flowers had appeared. The one on which the most complete series of observations was made was first observed on Sept. 21st, at 10 A.M., when the apex of the flower-bud was 5 in. below the surface of the water, or the flower-bud and peduncle measured together 3 in. In two days and a half, or by 4 P.M. on the 24th, the peduncle had reached the length of 10·7 inches, or, when straightened, the base of the unopened flower-bud was 2·7 inches above the water, the bud, enveloped in its spathe, being 0·5 in. in length. The following were the successive measurements :—

		inches.	Increase.
Peduncle and bud.....	Sept. 21st, 10 A.M.	3	
,,	22nd, 10 A.M.	4·75	1·75
,,	12 noon	5	·25
,,	2 P.M.	5·2	·2
,,	8 P.M.	5·5	·3
,,	10 P.M.	5·75	·25
,,	23rd, 9 A.M.	7·25	1·5
,,	12 noon	7·6	·35
,,	3 P.M.	8·0	·4
Peduncle only	Sept. 23rd, 6 P.M.	8·0	·5
,,	10 P.M.	8·4	·4
,,	24th, 8.30 A.M.	10·0	1·6
,,	4 P.M.	10·7	·7

During the three portions of days constituting this period, the growth was at the rate respectively of 1·75, 2·5, and 3·25 in. in twenty-four hours.

At this stage it seemed possible to measure the rate of growth of different zones of that portion of the flower-stalk which, when straightened, was exposed above the surface. As, however, neither of the "auxanometers," or instruments for measuring growth, described by Sachs in his 'Text-book' can be used for weak stems which do not naturally stand erect, the only available mode appeared to be to mark off at intervals of time measured lengths from the base of the flower-bud. This was done (but necessarily, from my engagements, at very unequal intervals) with black varnish, each length of one inch being marked off as it rose (when straightened) above the surface of the water, and indicated successively as A, B, C, &c., any fraction of an inch remaining over being added to the subaqueous portion. The following table exhibits the result, neither the final length attained nor the rapidity of growth being so great as in July, as, indeed, might have been expected.

	A	B	C	D	E	F	G	H	I	K	L	M	Subaq.	Total.	Incr.
Sept. 24th, 4 P.M.	1·0	1·0	..	..	..	..	..	..	..	..	..	..	8·7	10·7	
10 P.M.	1·0	1·0	1·0	..	..	..	..	..	..	..	..	..	8·0	11·0	·3
25th, 8 A.M.	1·1	1·1	1·1	1·0	..	..	..	..	..	..	..	..	8·1	12·4	1·4
27th, 10 A.M.	2·25	2·5	1·8	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	..	8·8	23·35	10·95
2.30 P.M.	2·6	2·75	1·9	1·15	1·15	1·1	1·05	1·05	1·0	1·0	1·0	1·0	8·1	24·85	1·5
10 P.M.	2·75	2·9	2·0	1·15	1·15	1·15	1·1	1·1	1·1	1·1	1·1	1·05	8·5	26·15	1·3
28th, 9 A.M.	2·9	3·0	2·1	1·15	1·15	1·15	1·15	1·1	1·1	1·1	1·1	1·1	8·75	26·85	·7
10 P.M.	3·1	3·1	2·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	8·75	27·45	·6
29th, 9 A.M.	3·25	3·23	2·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	8·8	27·75	·3
10 P.M.	3·25	3·25	2·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	1·15	8·8	27·75	·0

The general results arrived at are that between 4 P.M. on Sept. 24th and 9 A.M. on Sept. 29th the flower-stalk had increased in length from 10·7 to 27·75 in., the two zones immediately beneath the flower-bud from 2 in. to 6·5 in. This latter portion had increased during this period 225 per cent., the remainder of the flower-stalk 144 per cent. of its original length.

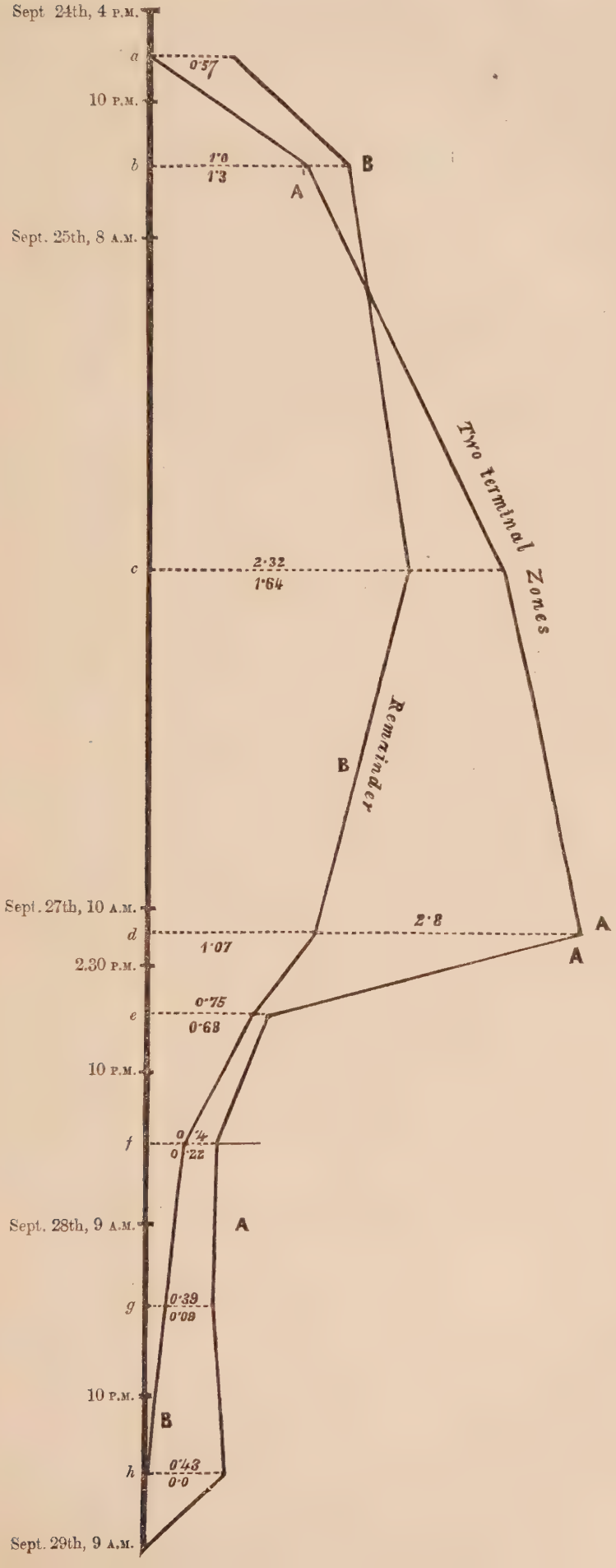
The term "Energy of Growth" of any particular part or zone of a plant is defined by Sachs ('Text-book,' p. 741) as "the power of that particular zone to attain a definite length." In the case of the stem of a plant consisting of a number of internodes, the measurements of Sachs, Pfeffer, and others show that the greatest energy of growth is generally displayed by an internode situated at some distance from the terminal bud, the energy of growth decreasing in the successive internodes, both towards the apex and towards the base of the stem. Similar careful measurements do not appear to have been made of the relative energy of growth of different portions of the same internode. In the case of the greatly elongated internode of *Vallisneria*, the maximum energy would appear to be very near the apex, the total energy of growth of the two terminal zones being to that of the remaining portion as 225 to 144, or nearly as 3 to 2. The energy would appear also, as far as any conclusion can be drawn from my few measurements, to decrease towards the base. For, dividing the portion of the flower-stalk excluding the

two terminal zones again into two parts, the uppermost of these (C–L) increased between 10 A.M. on Sept. 27th and 9 A.M. on Sept. 29th, from 9·8 to 11·35 in., or 15·8; the lowermost of them from 8·8 to 9·95 in., or only 13 per cent of its original length.

In calculating what Sachs terms the "Grand Curve of Growth" of the plant *, I have pursued a somewhat different plan to that adopted by this high authority. In his 'Text-book' (p. 737) he gives the following instructions for the construction of such a curve:—"If the increments of growth during successive equal times are drawn as ordinates, with the intervals of time as abscissæ, a curve will be obtained which, starting from the axis of abscissæ, reaches a maximum of elevation and returns again to the axis." In constructing these curves, it appeared to me that results of greater value would be obtained if, instead of the actual increment for any given time, the proportionate increase in relation to the length at the commencement of the interval were taken as the ordinate. By this means it seems to me that the energy of growth of each particular portion of the stem at any particular time will be represented by the altitude of the curve. Thus, supposing a stem increases during two successive equal intervals of time from 4 to 5 and from 5 to 6 inches, the energy of growth will not be equal to the two intervals, but will be less in the latter interval in the proportion of 4 to 5; inasmuch as it will have increased during the former interval 25 per cent., during the latter interval only 20 per cent. of its length at the commencement of that interval. It will be evident that though my grand curves of growth will agree with Prof. Sachs's in their general features, they will differ in minor particulars, and will in general be less abrupt. In constructing the curves from the data already given, I have first of all divided the increment during each interval of time by the length at the commencement of the interval, in order to get the proportionate increase as above indicated, and then the result by the number of hours in the interval, in order to reduce the times to a uniformity, the length of the intervals between the observations varying greatly, owing to my engagements. It is obviously, then, indifferent on what scale the curve is constructed, *i. e.* what is taken as the unit of measurement. In the diagram which accompanies this (p. 137), each unit of 1 inch on the ordinates represents an increase of 1 per cent. per hour; while an inch on the line of abscissæ represents a period of 12 hours. In accordance with Prof. Sachs's plan I have placed each ordinate in the centre of the abscissa to which it belongs. The two accompanying curves have thus been obtained, one exhibiting the variation of the energy of growth for the two terminal portions, the other for the remainder of the flower-stalk. The general result is seen to be that the terminal portion exhibits a considerably greater energy during the whole of the time with the exception of the first few hours.

A second series of observations was made on another flower-stalk; but I have not thought it worth while to record the results in detail, in consequence of an accidental injury (to which the slender and delicate stems are extremely liable when undergoing measurement), which both retarded the growth and caused it to be somewhat irregular. The curves constructed in the same manner showed a striking resemblance to those in the previous instances, but with two abrupt depressions caused by the injury referred to.

* See 'Arbeiten des botanischen Instituts in Würzburg,' 1873, Heft 2, t. i.



Curves of Growth of the two terminal zones and the remaining portion of the female flower-stalk of *Vallisneria spiralis*, Linn.

A. Grand curve of growth of the two terminal zones; B. Grand curve of growth of the remaining portion of flower-stalk. On the line of abscisse every inch represents a period of 12 hours; on the ordinates every inch represents a growth at the rate of 1 per cent. per hour. The figures above each ordinate express the growth of curve A, those below the ordinate the growth of curve B on this notation. The ordinates are erected from the centres of the several periods of time, *a*, *b c*, &c.

This flower-bud was first observed at 10 A.M. on Sept. 22nd, when its apex was 1 inch below the surface. By 9 A.M. on the 23rd, the total length of the peduncle was 9·75 in.; at 8.30 A.M. on the 24th, 13·95 in.; 8.30 A.M. on the 25th, 16·6 in.; 10 A.M. on the 27th, 19·0 in.; and at 9 A.M. on the 28th it had reached its ultimate length of 19·75 in. Two terminal zones, together 1·6 in. in length, were first marked off at 6 P.M. on Sept. 23rd, and had finally, at 9 A.M. on Sept. 28th, attained the length of 3·6 inches, or had increased 125 per cent. on the original length. The remainder of the stem had during the same time increased from 10 in. to 16·15 in. or 61·5 per cent. The total energy of growth of the terminal portion was therefore in this instance just double that of the remainder; but the latter had undoubtedly been checked by the accidental injury.

The flower-bud, when it first rose to the surface of the water in the aquarium, was ·5 in. in length, and closely enveloped in its spathe, from which it shortly afterwards gradually emerged, but did not open until the growth of the flower-stalk was nearly completed, when it had attained a length of ·75 in. The flower remains open floating on the surface for weeks, with the stigmas in an apparently receptive condition. By the time its growth is completed the flower-stalk has become very wavy, but does not coil up in shallow water when the flowers are unimpregnated.

The only record I have been able to find of observations on the rate of growth of different portions of the same internode is by J. Münter, in the first volume of the 'Botanische Zeitung' for 1843. He here lays down the general law that in the internodes of dicotyledonous plants the energy of growth, or, as he terms it, the *vis procreativa*, increases from below upwards, or may be described as centrifugal. This result he found most strikingly displayed in the peduncle and pedicels of *Pelargonium*, the only observations, I believe, which have hitherto been made on different parts of individual internodes *. It is interesting to compare this with the law of growth of stems taken as a whole, which is thus laid down by Sachs ('Text-book,' p. 740):—"As it is usual for several contiguous internodes of stems to be growing at the same time, and the maximum rapidity of growth occurs, according to circumstances, in the 2nd, 3rd, 4th, or 5th internode beneath the bud, the region of most rapid growth is at a considerable distance from the apex of the stem, and especially when the internodes attain a considerable length and several are growing at the same time. In roots, on the other hand, the maximum rapidity of growth occurs much nearer the *punctum vegetationis*, usually at a distance of only a few millimetres." It would appear, therefore, as if the phenomena of growth in the flower-stalk of *Vallisneria* exhibit a closer similarity to those of the roots than of the aerial stems of terrestrial plants.

* See also the reference to Münter's observations on the Hyacinth, *postea*, p. 143.

VII. *On the Growth of the Flower-stalk of the Hyacinth.* By Alfred W. Bennett, *M.A., B.Sc., F.L.S., Lecturer on Botany at St. Thomas's Hospital.*

Read March 16th, 1876.

In a paper which I had the honour of reading before the Society at its meeting on November 4th, 1875, I gave some details in respect of the remarkably rapid growth of the flower-stalk of the female flower of *Vallisneria spiralis*. The general results arrived at were that the greatest "Energy of Growth" was displayed by the apical portion of the peduncle or that immediately beneath the flower-bud, the energy apparently decreasing regularly towards the base of the flower-stalk. As this appeared to be opposed to the law stated by Sachs and others to govern the rate of growth of the different successive internodes of an aerial stem, I was anxious to ascertain how far it was in accord with the relative rapidity of growth of different portions of a single elongated aerial internode. For this purpose I have taken the earliest opportunity during the present spring of measuring the growth of the common peduncle of the inflorescence of the Hyacinth, with the following results in two specimens, one grown in a hyacinth-glass, the other in soil in a pot.

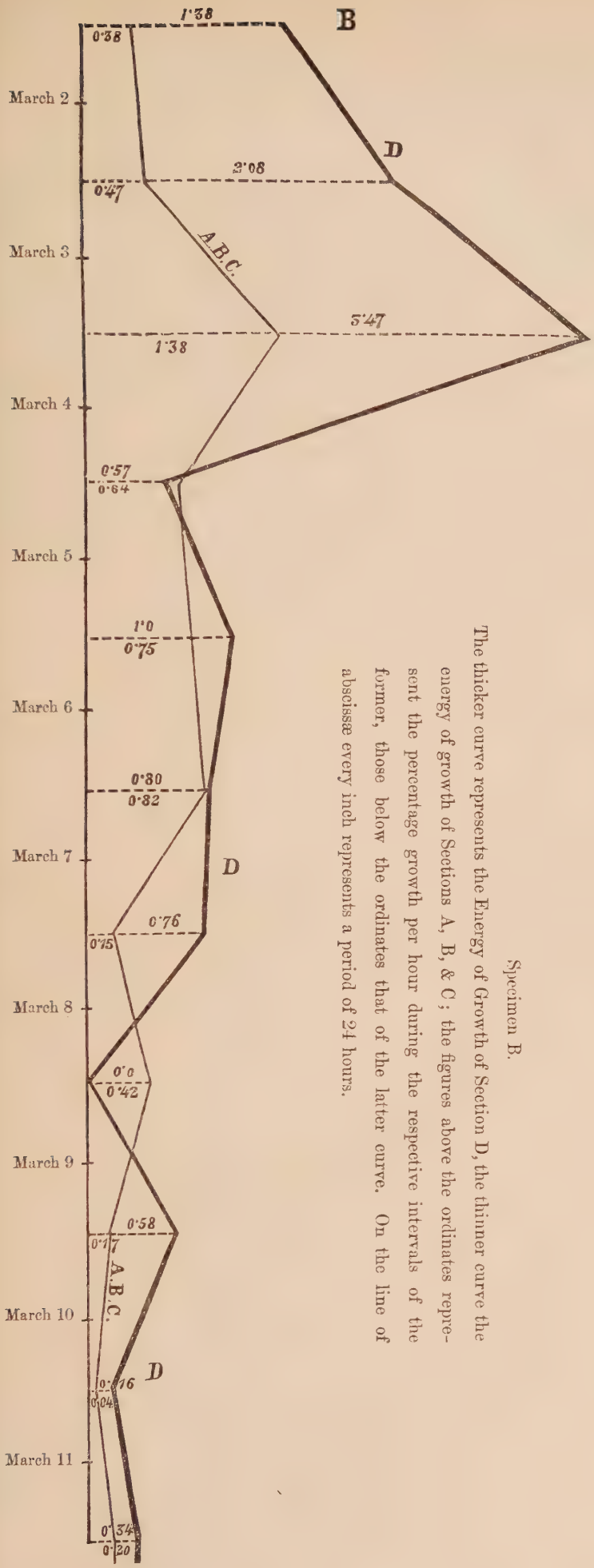
Specimen A, *grown in a hyacinth-glass.*

This was first measured at noon on Feb. 23rd, when the peduncle, with a total length of 1·25 in., was divided into two equal portions of 0·625 in. At 10 A.M. on the 26th, when it had increased to 1·55 in., each of the two sections was again divided, the length of the four portions, proceeding from above downwards, being 0·35, 0·4, 0·4, and 0·4 in. Measurements were made twice and sometimes three times a day; and it was soon evident that the energy of growth of these different portions was very unequal. By 10 P.M. on Feb. 29th each of the three uppermost portions was still only 0·5 in. long, whilst the lowest had increased to 1·0 in. From this time the increased rapidity of growth of the lowest portion was still more marked. By 10 P.M. on March 5th the lengths were respectively 0·9, 0·9, 0·85, and 2·35 in., and at 10 P.M. on March 11th, when the growth had finally ceased, the measurements were 1·15, 1·0, 1·0, and 3·45 in., making a total of 6·6 in. The following is a complete table of the measurements:—

	A	B	C	D	Total.	Increase.
Feb. 26th, 10 A.M.	·35	·4	·4	·4	1·55	
12 noon	·35	·4	·4	·45	1·6	·05
10 P.M.	·35	·4	·4	·5	1·65	·05
27th, 1 P.M.	·4	·4	·4	·55	1·75	·1
10 P.M.	·4	·4	·4	·55	1·75	·0
28th, 10 A.M.	·45	·4	·4	·65	1·9	·15
3 P.M.	·45	·4	·4	·7	1·95	·05

	A	B	C	D	Total.	Increase.
Feb. 28th, 10 P.M.	·45	·45	·4	·75	2·05	·1
29th, 10 A.M.	·5	·45	·45	·8	2·2	·15
3 P.M.	·5	·5	·45	·95	2·4	·2
10 P.M.	·5	·5	·5	1·0	2·5	·1
March 1st, 10 A.M.	·55	·55	·5	1·2	2·8	·3
10 P.M.	·6	·55	·5	1·25	2·9	·1
2nd, 10 A.M.	·65	·6	·55	1·3	3·1	·2
6 P.M.	·7	·65	·55	1·35	3·25	·15
3rd, 10 A.M.	·75	·65	·6	1·5	3·5	·25
3 P.M.	·75	·7	·6	1·7	3·75	·25
10 P.M.	·8	·7	·6	1·9	4·0	·25
4th, 10 A.M.	·8	·75	·75	2·2	4·5	·5
10 P.M.	·85	·8	·8	2·3	4·75	·25
5th, 10 A.M.	·85	·8	·8	2·3	4·75	·0
10 P.M.	·9	·9	·85	2·35	5·0	·25
6th, 10 A.M.	·95	·9	·9	2·5	5·25	·25
10 P.M.	1·0	·9	·9	2·7	5·5	·25
7th, 10 A.M.	1·0	·9	·9	2·75	5·55	·05
10 P.M.	1·0	·9	·95	2·9	5·75	·2
8th, 10 A.M.	1·05	·9	1·0	3·0	6·0	·25
10 P.M.	1·1	1·0	1·0	3·15	6·25	·25
9th, 10 A.M.	1·1	1·0	1·0	3·2	6·3	·05
11 P.M.	1·15	1·0	1·0	3·25	6·4	·1
10th, 10 A.M.	1·15	1·0	1·0	3·4	6·55	·15
10 P.M.	1·15	1·0	1·0	3·45	6·6	·05
11th, 10 A.M.	1·15	1·0	1·0	3·45	6·6	·0

It will be seen from the above table that by far the greatest total energy of growth was displayed by the lowest of the four segments, which increased during the twelve days between Feb. 26th and March 10th from 0·4 to 3·45 in., or 762·5 per cent. of its original length. The next greatest energy, but at a great interval, was exhibited by the apical section, which increased from 0·35 to 1·15, or 228 per cent., while the two central portions exhibited the least activity, increasing only from 0·4 to 1·0, or 150 per cent. of their original length. Dividing the peduncle into an upper and a lower half, and constructing the " Curve of Growth " in the same manner as those given for *Vallisneria* (p. 137), the accompanying diagram (Curve A) represents the results diagrammatically. On the ordinates, again, 1 in. represents a growth of 1 per cent. per hour on the length at the commencement of each interval; but each inch on the line of abscissæ represents a period, not of 12 but of 24 hours. In order, therefore, to compare the curve of growth of the Hyacinth with that of *Vallisneria*, the former ought to be flattened out so as to occupy twice the space. It will be seen that the rate of growth was subject to great variations on different days, dependent, no doubt, on the temperature and other causes. Making the division between day and night at 10 A.M. and 10 P.M., the growth was nearly equally divided between them, the 5 inches growth between Feb. 26th and March 10th being accounted for by about 2·65 in the daytime and 2·35 at night.



Specimen A.

The thicker curve represents the Energy of Growth of Sections C & D, the thinner curve the energy of growth of Sections A & B; the figures above the ordinates represent the percentage growth per hour during the respective intervals of the former, those below the ordinates that of the latter curve. On the line of abscissæ every inch represents a period of 24 hours.

Specimen B.

The thicker curve represents the Energy of Growth of Section D, the thinner curve the energy of growth of Sections A, B, & C; the figures above the ordinates represent the percentage growth per hour during the respective intervals of the former, those below the ordinates that of the latter curve. On the line of abscissæ every inch represents a period of 24 hours.

Specimen B, *grown in a pot.*

In the second example, the evidence was still more conclusive that the growth of the peduncle is mainly basilar. On Feb. 26th, the flower-stalk, then an inch in length, was divided into two equal portions of 0·5 in. On the next day, when it had increased to 1·1 in., the lowest zone of 0·1 in. was marked off separately. By 10 P.M. on Feb. 29th this lowest zone (C+D) had increased to 0·7 in., or by 600 per cent. of its original length, while the two uppermost zones were still respectively only 0·55 and 0·5 in. long. The lowest zone was then again divided into two portions, the upper one being 0·5 and the lower 0·2 in. long. By 10 P.M. on March 3rd the lengths of the four zones, commencing from the top, were 0·8, 0·8, 0·75, and 0·75 in., giving a total of 3·1 in. At 10 P.M. on the 7th, the total length of 6·5 in. was distributed thus :—1·6, 1·5, 1·25, and 2·15 in. ; and at 10 A.M. on the 13th, when the final length of 8·2 inches had been attained, the measurements were respectively 2·2, 1·75, 1·5, and 2·75 in. The following is the complete table :—

	A	B	C	D	Total.	Increase.
Feb. 26th, 9 A.M.	·5	·5	..	..	1·0	
10 P.M.	·5	·5	..	..	1·0	·0
27th, 1 P.M.	·5	·55	..	..	1·05	·05
10 P.M.	·5	·5	·1	..	1·1	·05
28th, 9 A.M.	·5	·5	·2	..	1·2	·1
3 P.M.	·5	·5	·2	..	1·2	·0
10 P.M.	·5	·5	·2	..	1·2	·0
29th, 9 A.M.	·55	·5	·45	..	1·5	·3
10 P.M.	·55	·5	·5	·2	1·75	·25
March 1st, 10 A.M.	·55	·55	·5	·3	1·9	·15
10 P.M.	·6	·55	·55	·3	2·0	·1
2nd, 9 A.M.	·6	·6	·55	·4	2·15	·15
6 P.M.	·65	·6	·55	·5	2·3	·15
3rd, 10 A.M.	·65	·65	·65	·6	2·55	·25
3 P.M.	·75	·75	·65	·65	2·8	·25
10 P.M.	·8	·8	·75	·75	3·1	·3
4th, 10 A.M.	·9	·9	·8	1·1	3·7	·6
10 P.M.	·9	·9	·85	1·25	3·9	·2
5th, 10 A.M.	1·0	1·0	1·0	1·25	4·25	·35
10 P.M.	1·05	1·1	1·1	1·25	4·5	·25
6th, 10 A.M.	1·2	1·25	1·1	1·55	5·1	·6
10 P.M.	1·35	1·3	1·2	1·75	5·6	·5
7th, 10 A.M.	1·5	1·5	1·25	1·85	6·1	·5
10 P.M.	1·6	1·5	1·25	2·15	6·5	·4
8th, 10 A.M.	1·65	1·5	1·25	2·15	6·55	·05
10 P.M.	1·7	1·55	1·35	2·15	6·75	·2
9th, 10 A.M.	1·85	1·6	1·4	2·15	7·0	·25
11 P.M.	2·0	1·65	1·4	2·35	7·4	·4
10th, 10 A.M.	2·0	1·65	1·4	2·45	7·5	·1
10 P.M.	2·0	1·65	1·4	2·45	7·5	·0
11th, 10 A.M.	2·0	1·65	1·45	2·55	7·65	·15
12th, 10 A.M.	2·15	1·7	1·5	2·75	8·1	·45
10 P.M.	2·15	1·7	1·5	2.75	8·1	·0
13th, 10 A.M.	2·2	1·75	1·5	2·75	8·2	·1
10 P.M.	2·2	1·75	1·5	2·75	8·2	·0

Starting from the measurement at 10 P.M. on Feb. 27th, the lowest of the three zones, which then measured 0·1 in., had increased by March 13th so as to make up the two zones C & D together 4·25 in., or 4150 per cent. of its original length, while the remainder had only increased from 1·0 to 3·95, or at the rate of 295 per cent. Again, starting from 10 P.M. on March 29th, when the four zones were first marked off, the ultimate increase of the lowest was from 0·2 to 2·75 in., or 1275 per cent.; the next greatest energy was displayed by the uppermost, which increased from 0·55 to 2·2, or just 300 per cent.; next came the second zone from the top, which showed an increase from 0·5 to 1·75, or 250 per cent.; and finally the third from the top, showing an increase from 0·5 to 1·5 in., or exactly 200 per cent. The curve B in the accompanying diagram (p. 141) illustrates the total energy of growth of Section D as compared with that of Sections A, B, and C taken together, the former being, as in the case of the previous curve, in excess during almost the whole period of growth. The rate of growth was again subject to great irregularities, which will be seen to correspond to a considerable extent to those of curve A, and were no doubt attributable mainly to changes in temperature. Making the division between day and night as before at 10 A.M. and 10 P.M., the total amount of growth was again not very different in the two; but instead of being, as in the previous case, slightly in favour of the day, was rather more decidedly in favour of the night; of the 6·5 in. growth from Feb. 29th to March 13th, 3 inches was by day, and 3·5 inches by night.

It will therefore be seen that, as far as these observations on the relative growth of different portions of the same internode go, they are entirely in accord with the statement of Prof. Sachs (*vide ante*, p. 135), in regard to that of different internodes on the same branch, that the maximum energy of growth is exhibited at a period considerably below the *punctum vegetationis*, though it is here much nearer the base than in the cases measured by Sachs. This brings out into still stronger relief the opposite phenomenon displayed by the elongated submerged flower-stalk of *Vallisneria*, the energy of growth of which is manifested mainly in the apical portion. The elongation of the peduncle of the Hyacinth continues considerably after the complete expansion of the flowers, until the lowest in the raceme begin to fade.

These observations differ in several points from those on the flower-stalk of the Hyacinth recorded by Münter in the 'Botanische Zeitung' for 1843, Feb. 24; but as he gives no measurements, I cannot think that these latter are of very great weight. He describes its growth as not centrifugal, like that of most flower-stalks, but centripetal; that is, it ceases to grow first near the flower and finally at the base. It will be seen that my two experiments (and I think the care with which the measurements were made precludes any possibility of mistake) agree in this, that while the energy of growth is greatest in the basal portion, the apical portion continues to grow for very nearly or quite as long. The growth of the flower-stalk of *Pelargonium* he describes, on the other hand, as centrifugal, the growth of each zone ceasing before the one next above it.

With regard to the relative amount of growth by day and by night, Münter also gives no measurements, but states that in the daytime the plant grows at first five times, then four times, and then three times stronger than by night. This differs materially from

the general law as stated by Sachs ('Text-book,' English ed. p. 749 *et seq.*), that "the plant will, according to circumstances, sometimes grow more quickly by day, sometimes by night, without exhibiting any exactly recurrent periodicity," the difference, however, being never so great as that stated by Münter. My own observations are more in accordance with this.

Since writing the above, my attention has been called by Prof. Sachs to a series of papers by Reinke in the 'Botanische Zeitung' for the present year, on the phenomena of growth of stems. His experiments were made entirely on the flower-stems of Endogens, chiefly *Juncus*, *Scirpus*, and *Narcissus*; but the only point that bears on the present inquiry is the statement that "the part of *Narcissus* in which growth takes place is entirely beneath the earth, and of the rushes within the leaf-sheath, all the parts which rise above the earth having already completed their growth." Unfortunately Reinke does not give the measurements on which he founds this statement; and, if correct, it presents a singular want of harmony with the law of growth exhibited in the Hyacinth. The point seems to deserve further careful investigation.

A very few measurements which I made on the leaves of the Hyacinth indicate that the increase in length in them takes place *entirely* in the basal portion, at least after they have attained a considerable length (see Sachs, 'Text-book,' English ed. p. 137). Whether, however, the cell-division is carried on actually beneath the surface of the soil, as stated by Reinke to be the case in the stem of *Narcissus*, I am unable to say.

VIII. *New British Lichens.* *By the Rev.* W. A. Leighton, *B.A. Camb., F.L.S., F.B.S.Ed.*

(Plate XXII.)

Read February 3rd, 1876.

Verrucaria myriospora, Leight. *Pale yellowish*, filmy, very thin, effuse or determinate by a pale brown watery line; *apothecia shining black*, moderate in size, numerous, round or oblong, often difformed by confluence, sessile and conspicuous, *hemispherico-subpapillate*; epithecium a very minute pore in the apex of the papilla; *perithecium dimidiate, spreading at the base, carbonaceous*; asci narrow, linear-clavate; paraphyses few, very slender and delicate; *spores innumerable*, colourless, very minute, oblong or lineari-oblong, *simple*.

On young oaks, Kylemore and Doughruagh, co. Galway (October 1875), *Mr. Larbalestier*.

A singular and peculiar species, differing in its general aspect and its innumerable very minute spores from any described species. Spores ·003 mm. long, ·0015 mm. broad. Spermogonia numerous, minute, roundish or clavate, black like the apothecia. Spermatia large, linear, arcuate. Gelatina hymenia I—.

Verrucaria succina, Leight. *Thallus fuscescent*, thin, effuse, scarcely if at all surrounding the base of the apothecia; *apothecia amber-colour*, numerous, large, *hemispherico-conical, papillate*; *perithecium amber-colour throughout, dimidiate, spreading at the base*; epithecium a minute pore in the apex of the papilla; paraphyses very delicate and slender; asci lineari-clavate; *spores* 8, colourless, *broadly fusiform*, 7-*septate*, large.

On moist rocks near the lake, Kylemore, co. Galway, very rare, *Mr. Larbalestier* (1875).

The apothecia, when wetted, became of a beautiful transparent amber-colour. Spores ·046 mm. long, ·008 mm. broad. No spermogonia detected. Iodine has very slight if any reaction on the asci and spores. Its nearest ally would seem to be *V. illinita*, Nyl.; but that species differs in having a whitish thallus, nigricant apothecia, the perithecium colourless in the lower part, and fuscous in the upper part, and iodine turning the asci and spores of a dirty deep brown, and is also a corticolar lichen. *V. succina* differs also in the size and colour of the apothecia from *V. chlorotica* (Ach.), which is consociate on the same rock, and which has also smaller 3-septate fusiform spores.

Lecidea subdiluta, Leight. Thallus of a *dark dirty sea-green colour*, thin, effuse, *continuous*, very slightly rimulose; *apothecia pale, waxy*, minute, *elevato-sessile*; *epithecium pale brown*, plane or concave, *surrounded by a thickish, pale, waxy, elevated*

margin; *hypothecium colourless*, or only very slightly yellowish at the very base; paraphyses indistinct, conglutinate, apices brown; *spores* 8, *colourless*, *oblong*, 1-*septate*, somewhat constricted in the middle.

On maritime rocks, Boulay Bay, Jersey, *Mr. Larbalestier* (May 1872).

Spores ·019 mm. long, ·0085 mm. broad. No spermogonia detected. Medulla I—. Gelatina hymenia I—.

This very interesting lichen was sent to me for determination by Mr. Larbalestier immediately on its discovery in 1872; and I at once saw that it was a new and distinct species, and named it *L. subdiluta*, from the general external resemblance of the apothecia to those of *L. diluta* (Pers.). This name I communicated to Mr. Larbalestier (*in litt.*) in 1872; and he subsequently deposited specimens with that name in Herb. Brit. Mus. and in several private herbaria. The lichen was subsequently shown by Mr. Larbalestier to Dr. Nylander, who, as Mr. Larbalestier informed me (*in litt.*), thought it "a seaside anomalous state of *L. prosechoides*, Nyl., and not worth distinguishing," which of course it is not. Since then Dr. Nylander has changed his opinion, and now describes it as a "species notabilis" in the 'Flora,' 1875, p. 442, under the name of *Lecanora jejuna*, Nyl. My name *L. subdiluta*, Leight., claims priority.

Lecidea advenula, Leight. Thallus *obsolete*; *apothecia nigro-fuscous*, minute, round, plane or subconvex, with a thin margin soon obliterated, *brownish within*; paraphyses indistinct, conglutinate, apices large, nigro-fuscous; *hypothecium thickish*, *nigro-fuscous*; *spores* 8, *nigro-fuscous*, *oblong*, 1-*septate*.

Parasitic on *Pertusaria sulphurea* (K yellow, C orange-red).

On rocks, Llanbedrog, near Pwllheli, North Wales, 1874. Very rare.

A very singular lichen, not scattered uniformly over the matrix thallus, but occurring only on blackened patches formed by some conglomerate spherical brown alga at intervals over the thallus. Gelatina hymenia I—. Spores ·024 mm. long, ·013 mm. broad.

Melaspilea vermifera, Leight. Thallus *obsolete*; *apothecia black*, very minute, *irregularly angulari-oblong*, imbedded in the cortical layer, *when dry plane and surrounded by a minute upraised jagged margin* of the cortical layer, when wet planoconvex, the margin obliterated; hymenium pale; paraphyses very delicate and slender, apices pale; asci lineari-obovate; *spores innumerable*, colourless, *arranged spirally* in the ascus, cylindrico-fusiform, pointed and arcuate at each end, *vermiform*, 1-septate.

Parasitic on the thallus and apothecia of *Variolaria discoidea*, T. & B. (*Pertusaria globulifera*, Turn.).

On oaks, Trefriw, North Wales, 1874. Rare. Gelatina hymenia I—. Spores ·022 mm. long, ·002 mm. broad.

Arthonia punctilliformis, Leight. Thallus a mere film; *ardellæ nigro-fuscous*, *excessively minute*, not larger than a pin's point, irregularly roundish, convex, scattered,

C.Berjeau lith.

internally brown; asci pyriform; paraphyses none; *spores* 8, *pale fuscescent, oblongo-clavate*, 1-*septate*, large.

On holly, Trefriw, North Wales, 1874, very rare. Spores ·029 mm. long, ·0135 mm. broad.

DESCRIPTION OF PLATE XXII.

Fig. 1. *Verrucaria myriospora*, nat. size.
2. Same lichen, enlarged.
3. Section of perithecium.
4. Asci.
5. Spores, magnified 1200 times.
6. Spermogonia.
7. Spermatia, magnified 330 times.
8. *Verrucaria succina*, its apothecium and perithecium, magnified.
9. Apothecium as seen from above, showing papilla and epithecium.
10. Structure of perithecium.
11. Spore, magnified 1200 times.
12. Paraphyses.
13. *Lecidea subdiluta*, nat. size.
14. Apothecium, magnified to show its peculiar elevato-sessile character.
15. Section of apothecium.
16. Spores, magnified 1200 times.
17. *Lecidea advenula*, nat. size.
18. Enlarged representation of the same.
19. Section of apothecium.
20. Spores, magnified 1200 times.
21. *Melaspilea vermifera*: apothecia, magnified, as seen from above in dry state.
22. Apothecia wetted, magnified.
23. Paraphyses.
24. Ascus.
25. Spores, magnified 1200 times.
26. *Arthonia punctilliformis*, nat. size.
27. Ascus.
28. Spore, magnified 1200 times.

IX. *On the Hygroscopic Mechanism by which certain Seeds are enabled to bury themselves in the Ground.* By Francis Darwin, *M.B., F.L.S.*

(Plate XXIII.)

Read March 16, 1876.

THE object of this paper is to describe the hygroscopic mechanism by which certain seeds are enabled to bury themselves in the ground. This phenomenon as it occurs in the Geraniaceæ has already been described by Hanstein *, and again by G. Roux † in the case of *Erodium*; lastly, Asa Gray ‡ briefly points out the power of burying themselves possessed by the carpels of some of the Western American species of this genus. After describing the process, he adds, "It is the same with the grain and awn of *Stipa*." I may mention that the latter note only appeared after I had completed my researches on this subject.

The species on which my observations have been made are *Stipa pennata*, *Avena elatior*, *Heteropogon contortus* (Bombay), *Heteropogon* (*Andropogon*) *melanocarpus*, (Florida), *Androscepia arundinacea*, *Anthesteria ciliata* § (Khasia), *Anemone montana* (from Switzerland).

It seems to me an extremely remarkable fact that the curious power of burying themselves should be exhibited by plants belonging to several distinct orders, and inhabiting various parts of the world; and that the mechanism should be essentially the same in all of them is even more remarkable.

My observations have been chiefly confined to *Stipa*; a short description of the caryopsis of this plant will explain the general method of action common to all the other fruits observed by me.

Fig. 1 represents the seed ‖ of *Stipa pennata*. It terminates inferiorly in a sharp strong oblique point (*p*) ¶, armed with a dense plume of barb-like hairs; $v\,k_1\,k_2\,f$ is the strong woody awn, of which the lower vertical part (*v*) is strongly twisted on its own axis, the appearance of the strands of a rope being given by the ribs *r* and *r*, fig. 9 (and seen in section in figs. 11 & 12), which run spirally up the awn. Above, the awn terminates in a long untwisted portion (*f*), bearing a series of beautiful hairs, giving its well-known feathery aspect: when the seed is dry this portion extends nearly horizontally outwards. The twisted and vertical part (*v*) is separated from the feathery part (*f*) by a curious double bend; the two angles thus formed I call the lower and the upper knee (k_1 and k_2).

* Sitzungsberichte d. Niederrhein. Gesell. Bonn, 1868. See Sachs, 'Botany,' Eng. Trans. p. 841, for abstract.

† Annales de la Soc. Bot. de Lyon, 1873.

‡ Silliman's Journal, Feb. 1876, p. 158.

§ Dr. Hooker most kindly supplied me with specimens of the four last-mentioned species.

‖ The use of this expression in place of the strict botanical term may perhaps be allowed me, on account of its greater convenience.

¶ Said to be capable of injuring the intestines of animals which feed on the grass (Hooker's Trans. of Decaisne and Le Maout, p. 892).

The hygroscopic action of the awn may be shown by holding the seed so that the twisted axis is vertical; on wetting the awn, the feathery portion will revolve, describing a circle in a horizontal plane; the vertical part untwisting, and its strand-like ribs becoming more and more oblique (*i. e.* making a smaller angle with the axis of the awn), until at last, when the awn is thoroughly wet, it shows no signs of torsion, and the two ribs run parallel to its axis down two of its opposite surfaces. As the awn untwists, the two knees, k_1 and k_2, are obliterated (k_1 disappearing first); by this means the feather is brought into line with the twisting part, and the awn forms a long straight pliable rod, pointing vertically upwards. It follows from this, that though the end of the feather begins (at the commencement of the wetting) by describing a circle, it ultimately describes a helix.

As the awn dries again, the action is exactly reversed: the axis becomes twisted; the two knees reappear; and the feather becomes again subhorizontal.

It was this remarkable property exhibited by *Stipa* of untwisting and twisting in response to alternations of moisture and drought, which convinced my father and myself that the whole structure must be adapted to some very definite end. We concluded that this object must be that of forcing the seed into the ground (in the manner to be immediately described). The sequel gives the result of my investigation of this point.

If in the above-described experiment the feather is prevented from revolving while the seed is left free, the untwisting of the vertical part of the awn will make the seed rotate on its axis. In consequence of the untwisting, the vertical part of the awn from the knee (k_1) to the tip of the seed becomes longer by about 7 per cent. Therefore, if we fix a dry *Stipa*-awn in a vertical position, the seed resting freely on the ground, and the feather being prevented from revolving, on wetting the awn the seed will rotate and will be pressed against the ground. But this requires that the expansion of the awn shall not be permitted to take place in an upward direction; *i. e.* the upper extremity must be fixed to give a *point d'appui*, from which the expansion may take effect in pressing the lower extremity against the soil.

In describing the untwisting of the axis it was stated that the angles k_1 and k_2 increase as the awn absorbs water, until the whole awn is converted into a straight rod. Now in the same way that, by interfering with its movements, the rotation of the feather is transferred to the seed, so by preventing the feather from rising to its full extent the tendency of the awn to become straight results in increased pressure of the point against the ground. The seed now resembles a brad-awl in exhibiting vertical pressure on a revolving point. In order that this action may take place in its entirety, three *points d'appui* are theoretically needed, although one is practically capable of performing the duties of all. The first is required, to transfer the rotation from the feather to the seed; the second, to force the expansion resulting from the untwisting of the awn to take effect downwards; the third, to convert the tendency of the awn to straighten itself into pressure of the seed against the ground. It is evident that if an awn be placed vertically, the seed resting on the ground, so that the feather can neither rotate nor describe any great angle in a vertical plane, all the required conditions will be fulfilled.

How can this be effected in a state of nature? Prof. Hildebrand has pointed

out * that the long feathery awn of *Stipa* serves as a "Verbreitungsmittel," or means of distribution. It is found that seeds dropped from a height of a few feet usually preserve a nearly vertical position, and strike the ground with their point. Moreover, if they are allowed to fall among low vegetation they are caught by the knees (k_1 k_2) or by the feather, and are fixed in a more or less oblique position, the seed resting on the ground. Many seeds would no doubt escape being entangled; and many others would be caught in unsuitable positions—suspended in the air, for instance, or making too acute an angle with the ground, or resting on some hard impenetrable body. Nevertheless many seeds are undoubtedly caught and held fast in suitable positions. The great length of the feather (nearly 30 cm.) would render entanglement in low vegetation an easy matter; and when a seed is once entangled the hairs serve to hold it fast and prevent the wind blowing it away.

In order to ascertain what would occur under these circumstances, I made experiments of the following kind:—A vessel being filled with dry sand or light soil, two upright sticks were fixed at about a centimetre apart; and these were connected at the height of 8 or 9 cm. from the surface of the soil by a cross pin, a second one being fixed 2 or 3 cm. higher up. The *Stipa*-seed is then placed with its point resting on the soil, and its feathery awn passed through the loophole between the two supports and the two cross pins. The whole is now placed under a bell glass lined with wet blotting-paper. This is better than wetting the awn directly; for in touching it with a wet brush it is possible to push it into the soil without being aware of it, and in syringing it the soil may become too much wetted. In order to dry the awn it is merely necessary to remove the glass; thus by alternations of dryness and moisture the awn is made to twist and untwist, just as it would under the changing hygrometric conditions of dew and sunshine in a state of nature. The amount buried may then be measured with a pair of compasses. It is very important to estimate the amounts buried, by measuring from the surface of the soil to the top of the *seed*, and not to any marked point in the awn; for in the latter case the measurements will be obviously inaccurate, owing to the lengthening and shortening of the awn.

All the movements of the awn are far more conveniently studied when the seed is fixed and the feather free to rotate; and in taking the times of rotations &c. I have found it best always to employ immersion in water in preference to exposing the awn to a damp atmosphere; for by the former means a constant amount of moisture is secured, and in nature the awn must be frequently exposed to an amount of moisture practically equivalent to immersion.

A dry *Stipa*-awn plunged into water at the temperature of the room began to rotate within a second of its immersion, and untwisted at the rate given in the following table:—

* Verbreitungsmittel der Gramineen-Früchte, Bot. Zeit. 1872, No. 49.

Turn.	Completed in	Turn.	Completed in
	M. S.		M. S.
No. 1	2 30	No. 6	1 30
2	2 0	7	1 45
3	1 45	8	2 10
4	1 35	9	3 20
5	1 25	10	

Thus the rate increases up to the 5th revolution, and then diminishes quickly.

The lower bend or knee is obliterated in from 20′ to 30′; the awn becomes completely untwisted in from $\frac{3}{4}$ to 1 hour; in doing so it increases in length by about 7 per cent.; a well-grown awn measures from the point of the seed to this lower bend 70 mm. dry, 75 wet. The upper knee disappears in periods of time which are rather variable, and lie between two and three hours. The movement which takes place as the awn untwists or twists is a combination of two rotations: the first is that due to the torsion of the vertical portion of the awn (50–55 mm.) from the lower knee down to the seed; the other rotation is due to the torsion of the short portion (15–18 mm.) between the knees. This latter axis is carried round quite independently of its own torsion, by the torsion of the long vertical axis; thus the portion $k_1 k_2$ (fig. 1) describes a cone about an axis of rotation which is continuous with v; and, again, owing to the torsion of the part $k_1 k_2$, the feather is made to rotate, describing a figure of rotation having a line continuous with $k_1 k_2$ for its axis. We have seen that the feather is usually nearly horizontal when dry, and vertical when wet (the seed being held vertically in both cases); it follows that in passing from the wet to the dry state the tip of the feather does not describe a regular helix, as would be the case if there were only one bend, but a complex figure varying with the varying relations between the rotations due to the two axes v and $k_1 k_2$. The rotations due to the untwisting of $k_1 k_2$ are slow (7–13 minutes); and since but two revolutions are possible, owing to the shortness of this part, their effect is not always great on the revolutions due to the untwisting of the vertical axis, which are from 13 to 16 in number. The rotation of the awn is best studied by fixing the seed while the upper end is allowed to revolve; and by the experience gained in this way it is possible to understand what occurs in the experiments on artificial burying where the awn is fixed while the seed is free to rotate. When an awn has been placed for several hours in the damp chamber, fixed in the kind of support described, it will not always be found to have buried itself. I have often found that the point of the seed has been dragged across the soil into which it should have thrust itself; and in these cases it has happened that the seed has been pushed down over the edge of the vessel, so that it would have tended to bury itself if the soil had been of a larger area. It is this dragging motion which I believe to be produced by the torsion of the short axis between k_1 and k_2 (fig. 1); for just as, when the awn is free, irregular movements are impressed on its rotation, so the tendency to irregular rotation is transferred to the seed when the awn is fixed. In other cases the experiment is successful, and the seed is found buried to a certain depth; the sand is often found disturbed close around the point, owing, no

doubt, to the irregularity of the rotatory motion of the awn. The following measurements give the amounts buried in three cases during a single wetting:—

I.

3 P.M.—A seed of 16 mm. length, resting with its point on damp sand.
5 P.M.—14 mm. of seed projecting above soil.
9 A.M. (still wet).—10 mm. „ „
Amount buried 6 *mm.* (2 of them in 2 hours).

II.

5 P.M.—12 mm. of seed projecting.
9 A.M.— 7 mm. „ „
Amount buried 5 *mm.*

III.

11.0 A.M.—6 mm. of seed projecting.
3.15 A.M.—2 mm. „ „
Amount buried 4 *mm.*

On removing the bell glass—that is, on substituting a comparatively dry for a damp atmosphere—the awn begins at once, *i. e.* in less than one second, to twist in the opposite direction to the hands of a watch; and as the drying proceeds all the above-mentioned movements are reversed. The following are the times in which the first six revolutions were made in once instance:—

Turn.	Completed in	Turn.	Completed in
	M. S.		M. S.
No. 1	13 0	No. 4	2 30
2	9 0	5	6 0
3	5 0	6	7 30

the movement being slow at first, then becoming quicker, and then slow again.

The lower knee (k_1) becomes perceptible in from 5 to 10 minutes, the upper knee (k_2) begins to be perceptible in from 10 to 15 minutes. The whole process of drying cannot be said to be thoroughly complete under two hours (in an ordinary room in winter); but the movement during the second hour is extremely slow, and practically almost unimportant.

When the drying-process is finished an examination of the seed will show that one of three things has occurred:—

(i.) The upward traction which results from the return of the awn to its former dry condition frequently pulls the seed out of the soil, especially if the sand used in the experiment is dry.

(ii.) The seed may, however, be able to withstand the upward traction.

(iii.) It may actually be found to be buried deeper than it was at the commencement of the drying-process.

The following measurements give the amount buried in three instances during a single drying:—

I.

6.45 P.M.—9 mm. of seed projecting above surface.
8.15 A.M.—7 mm. „ „
Amount buried 2 mm.

II.

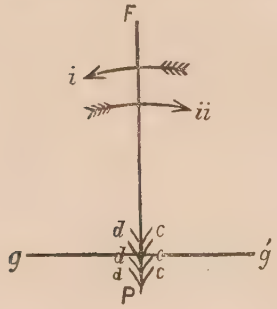
11.30 A.M.—12½ mm. projecting above surface.
1. 2 P.M.—10 mm. „ „
Amount buried 2½ mm.

III.

9 A.M.—10 mm. projecting above surface.
11 A.M.— 6 mm. „ „
Amount buried 4 mm.

In investigating the burial of the seed caused by drying, it must first be remarked that the plume of hairs with which the point is armed (see figs. 1 & 7) offers but little resistance to the entrance of the seed, but tends to prevent its withdrawal. The bare sharp point (*p*, figs. 1 & 7) is about ⅓ mm. in length; the hairs which form the plume are graduated, the smallest (¼ mm.) being the nearest to the point, so that they tend to preserve the smallest amounts buried during the wetting process. Moreover the length of the whole plume, measured from the extreme tip of the seed, is only about 4 mm.; and as we have seen that as much as 5 mm. may be buried in one wetting, it is quite conceivable that the seed can resist the uprooting tendency of the drying process. To understand how it can actually be buried deeper, we must examine more closely the act of rotation during drying.

A vertical rod, which is fixed at the upper extremity, will, as it twists on its axis, cause a simple rotation of its lower free extremity. But if the upper or fixed end is not vertically above the lower or revolving end, *i. e.* if the rod is curved, there will, I believe, be a tendency for the rotation to take place about the line joining the upper and lower ends of the rod. The movement imparted to the point will then resemble the circular rocking motion which is employed when a stick is being thrust into the ground. Given pressure from above, a rotating vertical rod will make a cylindrical hole of continually increasing depth; but if this pressure is removed, it will merely continue to rotate in the hole already made. But in the case of a *Stipa*-awn (a *curved* rod twisting on its axis), even when the pressure from above is removed the rocking* tends to continue the burying process. The point of the seed may be compared to a barbed point, like that in the woodcut.



The point P is supposed to be thrust into the ground, *g g′* giving the level of the soil.

* Whatever may be the explanation of this movement, it certainly occurs.

The free end F is now supposed to rock backwards and forwards, describing arcs alternately in directions *i* & *i i*, in the plane of the paper and about the point P. When F moves in direction *i* the barbs *d d d* will offer little resistance, whereas the barbs *c c c* will in fact act like fulcra, and will enable P to be forced deeper into the ground. On the movement being reversed, this action will be reversed also, *d d d* giving the fulcra, and P being again buried deeper. Although the tendency of a *Stipa*-awn, on drying, is to move (not backwards and forwards in one plane, but) so as to describe a cone, yet I believe the above-described process is essentially what occurs in *Stipa*; for the seed is revolving in soil of densities varying at different points, so that it moves not regularly, but by jerks; moreover the plume is rather more developed on two of the opposite surfaces of the seed than on the intermediate regions, and the point is obliquely set on. In observing the process of drying, I have often seen a distinct rocking movement as the awn attempted to rotate and was continually forced back again. All their aberrations from a structure and from a rotation of mathematical regularity must favour the levering or wriggling movement of which the diagram in the woodcut gives the essential action.

In describing the manner in which the seed of *Erodium* is buried during drying, Hanstein does not enter into any of the above considerations as to a rocking movement &c.; he merely says that "the lower part of the awn begins to contract into narrow spiral coils, causing the cone (*i. e.* seed) to turn on its axis and penetrate the ground; and the erect hairs on it, which point upwards, retain it there like grappling-hooks"*.

It has now been shown by what means the seed of *Stipa* is buried, both as it untwists and also as it returns to a state of torsion. By a combination of these two processes, the awn is thrust into the soil to such a depth as to cover up the seed completely. Thus, in an experiment, in three wettings and three dryings 28 mm. was buried in dry sand: the ordinary length of a seed is 17 mm.; so that this is amply sufficient. In another experiment a seed of 16 mm. length was completely buried in three wettings and three dryings. Another seed, which I entangled in the branches of a low bush, and left out of doors for eight days, had buried itself to a depth of 31 mm., impaling a piece of rotten leaf on its way. Mr. Farrer informs me that the *Stipa*-seeds which blow away from the parent plants succeed in burying themselves in his garden. The question of what advantage it is to the plant to bury its seeds will be discussed in the sequel.

Before passing on to describe the arrangement of structure of which the hygroscopic mechanism consists, I shall give a brief account of the phenomena exhibited by the *Stipa*-awn, considered merely as mechanical actions, and with no reference to the biological conditions in which they occur in Nature.

A simple instrument was made for me by my brother Horace: a piece of *Stipa*-awn, about 5 cm. in length, was employed, taking care to avoid either of the knees (k_1 or k_2). The awn is fixed at one end, and at the other bears a light index, fitted to travel round a clock-face as the awn twists or untwists; the bearing of the awn is so managed that the whole of it can be immersed in different fluids. The *Stipa*-awn is hygroscopically ex-

* Sachs, p. 841, Eng. Transl. (a perfectly correct abstract of the original).

tremely sensitive *; but as we shall see that it is also very sensitive to changes of temperature, a purely hygroscopic result is not so strikingly demonstrable as one due to a change in temperature and in moisture combined. Thus, breathing on the *Stipa*-hygroscope, held even at arm's length, or bringing the warm and moist hand near the awn, causes distinct movements of the index.

De Luc showed † that water has no *special* virtue in causing the expansion of hygroscopic bodies, and that other fluids can perform the office of filling out the molecular interstices. If the *Stipa*-hygroscope is allowed to dry in the air of an ordinary room, and is then plunged into absolute alcohol, the index shows, by moving in the "dry" direction, that water is being removed from the awn; after a time the alcohol itself is absorbed, and the movement of the index is reversed. On removing the instrument, the index moves in the "wet" direction, in consequence, I suppose, of the absorption of water by the alcohol; ultimately, however, the alcohol evaporates, and the movement of the index is reversed.

The effects of temperature on the awn are extremely curious, and agree with those observed by De Luc ‡: he found that a rise in temperature affects hygroscopic bodies in the same way as increased moisture, whereas a fall in temperature acts like dryness. With a *Stipa*-hygroscope the experiment is a pretty one; it is allowed to remain in warm water until the index comes to rest; if it is then removed, and plunged into cold water, the index gives a quick start through 90° or more in the direction of drying (*i.e.* against the hands of a watch). On replacing it in the warm water a rapid movement in the opposite, or "wet," direction takes place. The experiment may be performed in another way. If the hygroscope is placed in the current of hot air from a lamp, the rise in temperature tends to make the index move in the wet direction; but it also *dries* it, and therefore tends to make it rotate in the opposite direction: the struggle is made obvious by the fluttering motion of the index. The ultimate result is the victory of the "drying" rotation. The coincidence in the effects of heat and moisture accounts for the extreme sensitiveness of the *Stipa*-hygroscope to being breathed on.

The first theory which suggests itself to account for the effects of temperature is, that as an increase in the quantity of water in the molecular interstices makes the awn untwist, an increase in bulk of the water already permeating the tissues acts in the same manner. In support of this view my brother Horace showed that it cannot be due to *air* contained in the tissues; for the index does not move when the receiver of an air-pump under which it is placed is exhausted, or when the air is readmitted. In performing this experiment we immersed the hygroscope in oil or in mercury, to obviate the effects of the change of temperature resulting from the change of air pressure; before this precaution was taken the index moved distinctly as the air was removed or let in, although the thermometer only registered a change of 2° F.§

* It has been employed as a hygrometer (Watts, Dict. of Chemistry, iii. p. 233).

† Phil. Trans. 1791, p. 11. ‡ *Loc. cit.* p. 16.

§ The sensitiveness to changes in temperature was well exhibited by my brother, who observed that on lifting the *Stipa*-hygroscope out of water it always moved very slightly in the *cold* direction, but that this movement disappeared at the temperature of the dew-point, showing that it was due to evaporation.

My brother then suggested that if it were due to the expansion or contraction of the water contained in the tissues, the results ought to be exactly reversed when water at 4° C. was used as the higher temperature, 0° being the lower one, because water expands instead of contracting in passing from 4° to freezing-point, and therefore the *Stipa*-hygroscope ought to behave as if 0° was a higher temperature than 4°. Preliminary experiments showed that a difference of 4° is clearly indicated by the hygroscope; but, to our surprise, we found that the hygroscope behaves exactly as if water expanded in passing from 0° to 4°. We therefore concluded, like De Luc, that the effects of temperature have nothing to do with the expansion of water. He placed his hygrometer in quicklime, by which means he obtains what he calls "absolute dryness," and found that changes of temperature affected his instrument in "nearly the same" manner as when in water.

The only explanation left appears to be that the woody tissue itself expands with heat. But, from the experiments of Villari *, it appears that the expansion of dry wood with heat is *extremely* small compared with the expansion due to imbibition. I find it impossible to believe that the rapid rotation through a considerable angle is due to this cause. The following curious phenomenon negatives such a view, but must also remain quite unexplained. It will be made clear by detailing an experiment. Two vessels of water were employed, whose temperatures differed by about 63° C. In the cold water the index of the hygroscope stood at 130; on putting it into the hot water the index moved quickly to about 240 (not exactly noted), and returned slowly to 115. That is, it first makes a rapid *untwisting*, or *wet* movement, and then returns to a point on the *dry* side of its original position—that is, a point representing increased torsion of the awn; so that on moving into hot water it untwists rapidly, and then twists slowly up beyond its original degree of torsion. Exactly similar but reverse results ensue on removing the awn from hot to cold water. These experiments have been frequently repeated by my brother and by myself.

The Mechanism of Torsion.—In Sachs's 'Handbook' † the twisted growth of trees is explained by the internal parts not growing as fast as the external tissues, the unequal longitudinal tensions satisfying themselves by producing torsion. To apply this to the torsion of the *Stipa*-awn, we must suppose that, on drying, the internal parts contract more strongly than the external. This action may be imitated, as Sachs remarks, by slipping an elastic tube over a second of smaller calibre; the internal one is then stretched, the external one being left as it is, and the two are bound together in several places. On the release of the internal tube, the external one will not permit any shortening of the internal tube except by the whole system turning into an irregular helix. Hildebrand ‡ offers a similar explanation for the torsion of the awn of the "Springhafer" (*Avena sterilis*). He says that one surface of the awn contracts on drying more strongly than the opposite surface, and the awn twists on itself to satisfy the unequal tension thus produced. Hanstein § explains the torsion of the awns of the Geraniaceæ in a similar way. For a long time I concluded that some explanation of a kindred nature

* Quoted in Sachs: English Translation, p. 649.

† English Translation, 1874, p. 770.

‡ Pringsheim's Jahrb. für w. Bot. 1873, Bd. ix. "Schleuderfrüchte."

§ *Loc. cit.*

must hold good for *Stipa*. I assumed that if there existed unequal longitudinal tensions along opposite surfaces of the awn, there would be inequality of contraction or expansion in a radial direction, and that the sectional outline would alter in shape on drying. I could observe no such alteration, and found, in fact, that on swelling in water the awn increased in diameter very nearly equally in all directions. I concluded, therefore, that the inequality of expansion must be between the internal and external tissues, and not between two longitudinal halves. I saw no way of confirming or destroying this hypothesis; but I always felt a difficulty in the fact that the *Stipa*-awn is *always* twisted in one direction, whereas the above-mentioned unequal distribution of tensions would give a tendency to twist in either direction. Ultimately all theories of unequal contraction of the awn as a whole were overturned by observing that longitudinal sections and mere strips torn from the awn were capable of twisting up into precisely the same right-handed screw as the whole awn. This proved that torsion-power may reside in a combination of a few cells. The fact that a transverse section of the twisted awn of *Anemone montana* shows only broken-down tissue in the centre, convinced me that torsion is possible where the twisting-organ has *no* strongly contracting tissue in the centre. These two observations suggested that the power of torsion must reside in the individual cells composing the awn. I therefore boiled a piece of *Stipa*-awn in dilute nitric acid and chlorate of potassium; by subsequent teasing in a drop of water, the cells were isolated with great ease. The slip of glass was then held over a spirit-lamp, and a light teasing action continued, to prevent the cells adhering to the glass on drying. On examining the object under the microscope the torsion of the individual cells was beautifully seen; besides individual cells, numerous little ropes of two or three cells are seen, *all* twisted in the direction of torsion of the awn, *i. e.* that of a right-handed screw (see fig. 14).

To this observation it may be objected that the treatment with hot acid may have conferred the power of torsion on the cells. To this it may be answered, (1) that small portions, separated by *mechanical* means, exhibit torsion when dried; (2) that pieces of awn treated with boiling nitric acid and chlorate of potassium (if they are not teased into their constituent cells) undergo torsion on drying, proving that the cause of the torsion, whatever it be, is not affected by the treatment with acid.

I believe that both the internal and the external cells of the awn are capable of independent torsion; but whether this be so or not, it is certain that the small external cells exhibit the power in a far higher degree. This cleared up what had always seemed a great difficulty, viz. the instantaneous movements of the *Stipa*-hygroscope; for it removes the seat of hygroscopic action from the internal tissues to a more accessible part near the surface. In accordance with the present theory, it is found that the individual cells possess the same delicacy of action as the whole awn. I have actually seen a single cell under the microscope untwisting and twisting up again as my hand approached and was withdrawn from its neighbourhood.

Supposing it then to be granted that the cells composing the awn are capable of independent torsion, we have yet to show that the twisting of the awn as a whole will be

the result. The cells are of an elongated form, and are of course closely attached to one another, so that unless they are isolated they cannot twist on their own axis, since this would require a sliding movement between each cell and its neighbours. The following experiment demonstrates the way in which each cell satisfies its tendency to twist on its own axis.

A number of *Stipa*-awns (exclusive of feather and knees) are soaked in water, and when thoroughly untwisted are firmly tied into a cylindrical bundle or faggot. Here we have represented the state of things in an awn: each constituent awn in the bundle represents one of the cells of an awn, and, like them, tends to twist on its own axis on drying. It is found that, on drying, the bundle of awns is converted into a *rope*, its constituents passing helically round like the strands. And just in the same way the cells which make up an awn (of which the bundle of awns is a *schema*) satisfy their tendency to twist by forming a rope of cells twisted in the same direction as themselves.

If, then, we have a number of cells so connected together that they are incapable of independent torsion (and this is the case in the awn of *Stipa*), and if, further, each cell has a tendency to twist on its own axis (as we know to be the case with *Stipa*), then it cannot be doubted that the torsion of the mass of cells as a whole will be the result. That this is actually the mechanism by which the awn twists is conclusively shown by the fact that the constituent cells of the feathery non-twisting portion have *no* such power of independent torsion when isolated and dried in the manner already described.

The Bending of the Awn at the Knees (k_1 & k_2).—If we compare a section of the feather-bearing portion of the awn with a section of the twisting part, we find that the difference between them lies in this: in the twisting part the cells are all thick-walled (excepting the central ones, *c*, and two small masses, *m* & *m*, fig. 11); but in the feather all the cells are hollow, and it looks as if the central mass of thin-walled cells had increased so as to fill up the whole interior of the section. And since this thin-walled tissue is not hygroscopic in the feathery portion, we may assume that it is not so in the twisting part. Comparing a section taken low down in the awn (fig. 11) with one taken at the upper knee (fig. 13)*, we find a marked difference in the distribution of the non-hygroscopic tissue. At the upper knee the cells are passing into the hollow condition found in the feather; but this change does not attack all parts simultaneously: the small masses of non-hygroscopic tissue, *m* & *m*, have enlarged and coalesced with the central mass (*c*); and it is the cells surrounding the coalesced masses which exhibit the commencement of the loss of thickening in their walls. We may divide the section by a line *x y*, on one side of which there are many hollow cells, on the other all thick-walled cells. The twisting-power, which is already weak in the portion of the awn between the two knees, must be disappearing at k_2, since in the feather it is quite gone. When drying commences, the mass of thick-walled cells contract longitudinally; and the mass of hollow cells not being able to contract to the same extent, the awn will bend with the non-

* In the drawings of the sections, figs. 11, 12, & 13, the stratification of the cell-walls is not represented; nor are the pit-channels given, which are especially numerous in the large internal cells, and which seem to communicate with the vascular bundle in the centre.

hygroscopic half on the convex surface, and the strongly contracting cells on the concave aspect. To prove that the internal cells do contract longitudinally, it is only necessary to split an awn longitudinally; on drying, the split-off pieces bend with the internal surface concave. There can be no inherent tendency in the separate cells at k_2 to bend in the direction assumed by the awn; for a small portion severed by a longitudinal section (such as is shown by the upper dotted line, fig. 13) bends with the internal surface concave, which is in the opposite direction to that in which the whole awn bends.

The bending at the lower knee is more difficult to explain. The hollowing-out of the cells near *m* & *m* has begun even at this part of the awn: two hollow cells are shown in fig. 12; and in other sections I have found more of them occurring. In this section, again, we might draw a line which would divide the awn into a more and a less contractile half. In fact we have at the lower knee a bending-mechanism similar to that which exists at the upper knee, but with an important difference: at k_2 the torsion-power of the awn is exhausted, whereas at the lower knee this is not the case; and since the unequal longitudinal tension just described can satisfy itself by assisting the *torsion*, it does not seem evident how the *bending* of the awn is to be effected. To explain this a hitherto neglected point in the structure must be noticed. If we compare once more a section of the awn close to the seed with one taken at either of the two knees, we find that in the lower section (fig. 11) the ribs *r r*, are separated from one another by approximately equal portions of the circumference; but at the lower knee (fig. 12) the arc on the side *m m* has diminished, while the other has increased. In a wet or untwisted awn, the fact that the ribs approach one another as they pass from below upwards, gives the appearance of a very slight and elongated left-handed screw. And I believe that the approach of the ribs to one another is directly connected with the unequal arrangement of the more and less hygroscopic tissue at the knees. At the lower knee there is, moreover, a single sudden and short turn of a left-handed screw. This I call the "reverse twist," since it is in the opposite direction to that in which the awn twists in drying. The reverse twist is perfectly distinct from the ordinary hygroscopic torsion of the awn; for it is not obliterated by wetting, and is the result of the growth of the tissue into that shape. It is like a single turn of a fluted spiral column made of india-rubber, which could obviously be twisted in either direction independently of its shape. Now since the awn twists in the opposite direction to the reverse twist, the latter will be obliterated as torsion proceeds; and this is, in fact, the case: the awn is twisted both above and below the knee; but at the actual bending-place there is no torsion. When the reverse twist is obliterated, the unequal longitudinal tensions at the point k_1 are employed in producing the bend, instead of satisfying themselves in assisting the torsion. To summarize this imperfect explanation, the torsion-power satisfies itself in obliterating the reverse twist; and then the unequal tension, being brought into a longitudinal direction, satisfies itself by producing the bend.

I suspect it was the reverse twist which deceived Max Wichura*, and led him to describe the awn of *Stipa* as twisted to the right below the knee, and to the left above it.

* "On the winding of Leaves," Taylor's 'Scientific Memoirs,' May and Aug. 1853, p. 280; the original in 'Flora,' 1852, Jan. and Feb.

I have discussed the mechanism of the bend at some length, because of its extreme importance in the burying-process; for if the awn did not terminate above in a non-twisting horizontal portion, the rotation would not be transmitted to the point of the seed, neither could there be any increase of vertical pressure resulting from the straightening of the awn.

Torsion.—An explanation will now be attempted of the power of torsion which the cells possess.

It is a general property of hygroscopic tissue that the cells composing it are thick-walled. I have already pointed out the difference in this respect which exists between the hygroscopic and the non-hygroscopic tissue of the *Stipa*-awn. Hildebrand ("Schleuderfrüchte") mentions the thick-walled cells composing the awn of *Avena*. We should expect therefore that the power of torsion would depend on the manner in which the cell-walls are thickened.

Before discussing my view, it will be well, first of all, to exclude any cause resembling the unequal internal and external tensions which are supposed to account for the torsion of trees; for this only shifts the difficulty one step further off, and does not account for the constancy of *direction* of torsion. We may now examine the structure of the cells which make up the hygroscopic tissue. A body which swells on imbibing water will expand equally in all directions, if the molecular interstices in which the water lies are symmetrically arranged in all directions. And a cell will have no tendency to twist if its cell-wall expands equally in all directions. Therefore, if we are to account for the torsion of a cell by the expansion or contraction of its cell-wall, we must examine the molecular structure of the wall with special reference to the distribution of the capacity for absorbing water. The well-known researches of Nägeli * are directed to this very point.

He there shows that the cell-wall is composed of parallel lamellæ of alternate degrees of density and refractive indices. The first series of lamellæ are seen in transverse sections of elongated woody cells, as concentric shells, alternately light and dark, and fitting inside each other. This appearance is well known as stratification or "*Schichtung*." The other systems are essentially of the same nature, but are not so well marked. They give rise to the appearances known as "*Streifung*" or striation; these are series of parallel lines, alternately light and dark, traversing the surface of the cell, and are in reality the edges of parallel lamellæ of alternate densities. There are usually two systems of parallel lamellæ; and they may be inclined to the axis of the cell at almost any angle. Very frequently the two systems wind spirally round the axis in opposite directions. Now according to Hofmeister †, when the tissue of the cell-wall expands during imbibition, it is chiefly due to the swelling of the less-dense striæ; and we have seen that these striæ are spirally arranged; therefore we are led to expect that the imbibition of water will result in some kind of spiral tension: and spiral tension will result in torsion—just as when a string is fastened to one end of a rod, and is coiled spirally round it, and the free end is pulled, the rod will tend to rotate on its axis. And since there are two systems of spiral striation, the tension due to one system must be stronger than that

* Münchener Sitzungsb. 1864, May & July. † Lehre v. d. Pflanzenzelle, (1867) p. 197.

due to the other, if any tendency of the cell to twist in one direction more than in the other is to result. Nägeli has shown* that imbibition does lead to the torsion of a cell on its axis when one system of striation is more pronounced than the opposite. Fig. 10 is copied from his paper already quoted†: *a* shows a cotton-wool fibre in extremely dilute sulphuric acid; *b* is the same fibre in somewhat more concentrated acid. The first treatment merely brings out the striæ more clearly; the stronger acid causes the fibre to swell and to twist on its axis. The importance of these figures is this: in *a* it may be seen that the direction of the striation changes in the lower half of the fibre; and in *b* it is seen that the direction of the torsion changes precisely where the direction of the striation does; not only do cotton-wool fibres twist on the intense imbibition caused by acid, but, as I find, on the intense *abstraction* of water caused by strong drying. From these facts we must conclude that the striation of the cells is the cause of the torsion of fibres of cotton wool.

The elongated cells of the *Stipa*-awn present a close analogy with cotton-wool fibres; not only do they twist on drying, but also, as a result of the great swelling caused by maceration in strong Schultz's solution, they undergo torsion in the opposite direction.

From all these considerations, I cannot resist the conclusion that the torsion of the cells in the *Stipa*-awn is a direct consequence of unequal contraction of the cell-wall due to the striation of the membrane. I have found the investigation of the molecular structure of the cells in the *Stipa*-awn too difficult a task to be included in the present research; I believe, however, I may say that the cells are obliquely and spirally striated, and that one system is more strongly developed than the opposite.

Both Nägeli and Hofmeister give explanations of the ultimate mechanism of the torsion of cells; but in my present need of clear anatomical details it would be useless to apply their explanations to *Stipa*-cells.

I now pass on to describe the remaining seeds or fruits observed by me.

Avena elatior.

Professor Hildebrand has described the hygroscopic awn of *Avena sterilis*, both as to the mechanism of the twist and the adaptation of the hygroscopic torsion as a means of distribution‡.

Fig. 4 shows the awn of *Avena elatior* (the empty glumes having been removed). It will be seen that, supposing the fruit to be held vertically, we have, just as in *Stipa*, a vertical twisted part of the awn, and a more or less horizontal part which is not twisted. In *Avena sterilis*, according to Hildebrand§, the spikelet contains two fertile flowers, and therefore two bent awns. He describes how, in drying, the pressure of the rotating part of the awn against the ground causes the fruit to be projected into the air ("ein Stück fortgeschleudert wird")‖.

* Münchener Sitzungsb. 1864, July, p. 124. † Tab. i. figs. 8 & 9.

‡ Pringsheim's Jahrb. *loc. cit.*; and "Verbreitungsmittel der Gramineen-Früchte," Bot. Zeitung, no. 49, 1872.

§ Schleuderfrüchte, Separatabd. p. 14.

‖ This curious property has gained for it in Germany the popular name of "Springhafer" (*Hildebrand*). I have met with a curious mention of the wild oat in the 'The Young Man's Companion, or Arithmetic made easy,' 1727:—

He also describes a method of progression by turning over and over, and a kind of creeping movement caused by the extension and flexion of the awns. Prof. Hildebrand suggests that possibly the more important function of the twisted and bent awns of *Avena* and other grasses may be similar to that of *Erodium*, *i. e.* to bury the seeds in the ground. From analogy with *Stipa*, and from other considerations, there can be little doubt that this surmise is correct.

The fruit of *Avena elatior*, 6 times magnified, is given in fig. 4. The vertical part of the awn (attached to the outer palea or flowering glume) is about 5 mm. in length, and is strongly twisted into a right-handed screw of about 4 turns. It follows that, just as in *Stipa*, the horizontal portion (6 mm. long) revolves in the direction of the hands of a watch when the awn is wetted. It is more sensitive hygroscopically than *Stipa*, and untwists very quickly (one turn in from 15″ to 30″) when placed in water, as compared with the *Stipa*-hygroscope, which makes one revolution in 2 or 3 minutes.

It will be seen that the point is blunt, and that it is covered with a plume of hairs pointing backwards as in *Stipa*; but these hairs seem to me too weak to be of much service. The horizontal portion of the awn is not feathered, but armed (as is also the twisting part) with minute reflexed barbs. I have not succeeded in observing the process of burial in *Avena*; nor has Hildebrand seen it. But I found that the seeds of a patch of wild oats growing in a ploughed field had succeeded in burying themselves. I believe that the mechanism of burial is not quite the same in *Avena* as in *Stipa*; the seed is too heavy to be held vertically, and the awn does not seem fitted for so supporting it. Moreover the specimens which I found buried were not in a situation where low herbage could have entangled their awns, but among bare lumps of clay. I presume that the point is pushed laterally against inequalities in the ground, other projections being made use of as *points d'appui*.

In explaining the mechanism of torsion in *Avena*, I am compelled, unfortunately, to differ entirely from Prof. Hildebrand. His view has been already mentioned. Against it I bring forward the arguments:—

(i.) That it does not account for the direction of torsion being constantly the same.

(ii.) That the surface which he believes to be the most contractile is on the *convex* side at the bending-point.

(iii.) The strong argument that the cells, when isolated by nitric acid and chlorate of potassium, exhibit precisely the same power of independent torsion as those of the *Stipa*-awn.

The mechanism of the knee is, I believe, the same in *Avena* as in *Stipa*. Professor Hildebrand figures a section of this awn (which is morphologically identical with that of *Stipa*) as having two cavities answering to the hollow ribs of *Stipa*, and, like them, filled with cells containing chlorophyl in the young state. In this condition the ribs make an

"The following trick is made use of when any thing in a family is lost, to make the person suspected confess the fault and restore what is lost. Take a beard of wild oat while 'tis greenish, and twist it in the shape of a little cross, giving it to the person suspected, and whose guilt they are pretty well assured of. Give also to the rest of the family little crosses, but made of different stalks, as hay and wheat; put all these in a cut apple, and the little wild oat will grow sensible of the moisture, untwisting itself and turning, to the great amazement of all the spectators."

elongated turn in the direction opposed to the hygroscopic torsion of the awn; and this elongated "reverse twist" is seen in the mature awn when untwisted by wetting. This reverse twist is the consequence of the approach of the ribs to each other as they pass from the lower part of the awn to the point of bending; and I think that, as in *Stipa*, this alteration in form is connected with the longitudinal partition of the awn into a more and a less contractile half.

Heteropogon melanocarpus.

The general appearance of the awn of this species is shown in fig. 2. In an ordinary room in winter it has but one knee, as shown in the figure; but I have since found that by drying it at a higher temperature a lower knee appears; in the wet state a "reverse twist" can be made out. The seed has a sharp oblique point, and a well-developed plume of hairs; the awn, like that of *Stipa*, *Avena*, and *Anemone*, is twisted into a right-handed screw. There are no feathery hairs on the non-twisted part of the awn; but it is covered throughout its entire length with minute reflexed barbs. I find it capable of burying itself on becoming wet; but whether it does so on becoming dry I am not sure.

Heteropogon contortus

has a doubly bent twisted awn, of which the vertical part is roughly 13 mm., the part between the knees 10 mm., and the non-twisted part 4 cm. in length. It twists in the same direction as *Stipa* &c.; and, when wetted, I have found it able to thrust itself into sand.

Androscepia arundinacea.

The strongly bent and twisted awn is shown in fig. 3. I do not possess the complete fruit of this species, and could not make any trial of its burying-powers.

Anthesteria ciliata

somewhat resembles *Heteropogon melanocarpus*, with a bent and twisted awn, and a fine plume of hairs.

Lagurus ovatus has a bent and twisted hygroscopic awn. And I find the following kinds of grasses mentioned as having bent and twisted awns—*Aira*, *Arrhenatherum*, *Holcus**, *Streblochæta nutans*, *Danthonia*, *Chetobromus Dregeanus*, *Macrochloa arenaria*†. I think it is probable that these have the power of burying themselves.

RANUNCULACEÆ.

Anemone montana.

Fig. 6 gives the general appearance and proportions of the achene of this plant. The slight hairiness of the awn probably aids in the distribution of the seed. It is exceedingly remarkable that the general features of the above-mentioned burying-seeds, all members of the order of Grasses, should be repeated in a Ranunculaceous plant.

* 'British Flora,' Hooker.

† Max Wichura, translated in Taylor's Scientific Memoirs, May and Aug. 1853.

We have :—(1) seed more or less pointed, with a plume of hairs directed backwards (see fig. 8); (2) vertical awn twisting, when dried, into a right-handed screw; (3) horizontal, non-twisting portion rotating, when wet, in the direction of the hands of a watch, and coming into the same straight line with the lower part of the awn when the untwisting is complete; (4) cells of the twisting part capable of independent torsion.

With some difficulty I succeeded in observing the seed of *Anemone montana* bury itself almost completely during the process of becoming wet. I do not know whether it is capable of being buried deeper as it dries. Le Maout and Decaisne * figure the achene of *Anemone pulsatilla* as bent and twisted. Max Wichura† describes *Clematis azurea* as having the appendages to the carpels twisted.

GERANIACEÆ.

I merely mention this family to point out the general resemblance presented by the coccus and awn in some of its members to the burying-mechanisms already described. Fig. 5 (a dry *Pelargonium*-coccus) shows the flat, ribbon-like awn twisted into a right-handed screw, the knee, the horizontal non-twisted portion, the pointed fruit, and the plume of grappling-hairs.

It is undeniably true, as Hanstein points out, that the external surface contracts more strongly than the internal one in drying; but this does not account for the direction of torsion; I find that, as in the above-described awns, the cells are capable of independent torsion.

I have made no experiments on the burying-powers of the Geraniaceæ, as these have been already described by Hanstein, Roux, and Asa Gray.

When we find among organisms belonging to widely different groups a curious structural mechanism, repeating itself and performing in each case the same function, we conclude that this function is an important one in the economy of the plant. Thus, for instance, the importance of the distribution of seeds is pointed out by the existence of burs in widely different orders, such as the Compositæ (Burdock), Rosaceæ (*Geum*), and Rubiaceæ (*Galium aparine*)—of plumes to enable the seed to fly on the wind in many Compositæ, Apocynaceæ, Onagraceæ, &c.

Now in the burying seeds which we have been considering we have a similar case, a given function performed by essentially similar mechanism in plants belonging to widely different orders; and we accordingly conclude that the power of thrusting themselves into the ground is of special service to the seeds under consideration. Two theories suggest themselves.

(i.) My father has observed that certain seeds are almost incapable of germinating in the light, whereas they do so readily in the dark. This fact suggested that the power of self-burial has been developed to remedy the injury which the incapacity of the seeds to germinate in the light must cause to the species. I therefore made a comparative trial to determine this point. A number of *Stipa*-seeds were placed in a vessel half filled with

* English Translation, p. 175.

† Taylor's Scientific Memoirs, Aug. 1853, p. 302.

damp sand, and covered with a glass plate; half of the seeds were thrust into the sand*; the rest were allowed to remain on the surface. Contrary to my expectation, the seeds exposed to the light began to germinate first. I regret that I did not make a second trial with another lot of seeds; I think, however, that the above result is sufficient to overturn the theory in question, at least as far as *Stipa* is concerned †.

(ii.) The only other hypothesis which I have been able to form is, that by burying themselves in the ground the seeds are enabled to escape being eaten by birds. The fact that many of them are Gramineæ, and therefore likely to be sought after as food, favours this view ‡.

The developmental stages through which any structural mechanism has passed is always a most interesting question. Unfortunately I am as yet unable to enter into this question with respect to the burying seeds. We have seen that the mainspring of the mechanism is hygroscopic torsion; now many cells become twisted on drying, such as cotton-wool and bast fibres, the tubes of *Erineum* §, and curiously enough the beautifully striated cells which support the glands in *Byblis gigantea*.

Again, hygroscopic torsion depends on the spiral striation of the walls of the twisting cells. Now lamination or differentiation into more or less watery layers is probably a universal condition of the formation of cell-walls; so that the materials, as it were, for the development of hygroscopic torsion are certainly existent. The variability in the torsion of the cotton-wool cell shows that a want of unanimity in the direction of torsion would be one of the difficulties to be overcome in the process of development. Through what steps the hygroscopic sensitiveness has passed in development I am at a loss to say.

Finally, I venture to hope that my explanation of the torsion of awns may ultimately throw some light on other forms of torsion; and to this point I hope soon to direct my attention.

* For whatever reason the seed is buried, it would seem desirable that it should remain undisturbed. The joint by which the awn is attached to the seed seems adapted for this purpose; for after remaining a few days in damp soil the awn can be detached by the slightest touch. Roux points out the same thing in *Erodium*.

† G. Roux, *loc. cit.* states that *Erodium*-seeds germinate better when buried to the "normal" depth than when more or less deeply covered by soil. The details are not given in a manner to carry conviction.

‡ The seed of *Anemone montana* (one of the burying seeds) contains a large quantity of endosperm; the seed of this species is moreover, as far as I can make out, destitute of the acrid principle so common in the Ranunculaceæ, and which is found at least in some representatives of the neighbouring genus *Clematis*. Is it possible that the acrid principle may serve to prevent animals or birds eating the seeds of the Ranunculaceæ? as we know to be the case with the Bitter Almond ('Variation of Animals and Plants,' 2nd edit. vol. ii. p. 218). If so, the deficiency in the seed of *Anemone montana* of an acrid principle may be connected with the development of the burying-mechanism.

§ Sachs, 'Physiologie Végétale,' (translation: Geneva, 1868) p. 453, quoted from Nägeli and Cramer, 'Pflanzen-phys. Untersuch.'

Fig.1.
f
k2
k1
v
p
Fig.2.
f
v
p
Fig.3.
f
v
Fig.4.
×6
Fig.5.
f
v
×3½
p
Fig.6.
f
v
p
Fig.7.
×6½
Fig.8.
×5
Fig.9.
r
r
r
r
r
r
×7
Fig.10.
a
×200
b
Fig.11.
×80
c
r
r
m
m
Fig.12.
c
r
r
m
×80
m
Fig.13.
×80
y
x
r
r
m
m'
c
Fig.14.
×100

DESCRIPTION OF PLATE XXIII.

Fig. 1. Fruit and awn of *Stipa pennata* (natural size). *p*, the sharp point; *v*, the vertical twisted part of the awn; k_1 and k_2, the lower and upper knees; *f*, the non-twisted and more or less horizontal part of the awn.

2. Fruit and awn of *Heteropogon melanocarpus*. Letters corresponding to fig. 1.

3. Awn of *Androscepia arundinacea*. Letters as above.

4. Fruit and awn of *Avena elatior*. × 6.

5. Carpel and beak of *Pelargonium*. Letters as above. × 3½.

6. Achene and tail of *Anemone montana*. Letters as above: natural size.

7. Lower part of the fruit of *Stipa pennata*. × 6½.

8. Achene of *Anemone montana*. × 5 (about).

9. Upper part of *v* in fig. 1. × 7 (about). *r* and *r* are spirally running ribs, seen in section at *r* and *r* in figs. 11, 12, 13.

10. Cotton-wool cells. *a*, in dilute, *b*, in stronger sulphuric acid (from Nägeli). × 200.

11. Section of awn of *Stipa pennata* close to seed. *r* and *r* hollow spiral ribs (see fig. 9); *c*, central vascular bundle; *m* and *m* smaller masses of the same tissue; *c*, *m*, and *m* are non-hygroscopic. × 80.

12. Section of awn of *Stipa pennata* at k_1, fig. 1. Letters as in fig. 11. × 80.

13. Section of awn of *Stipa pennata* at k_2, fig. 1. Letters as in figs. 11 and 12. *x y*, line dividing awn into a more and a less hygroscopic part. On the other dotted line see text, p. 160. × 80.

14. External cells from the awn of *Stipa pennata*, isolated with nitric acid and chlorate of potash and then dried, to show the power of independent torsion residing in the cells of the awn. × about 100.